



ESN INFORMATION BULLETIN

European Science Notes Information Bulletin
Reports on Current
European/Middle Eastern Science

EUROPE 1992--a Dedicated Issue:

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<p>The European Science Notes Information Bulletin (ESNIB) 90-02 is dedicated to Europe 1992, The View From the Office of Naval Research European Office. Recent events in Eastern Europe are redirecting thoughts and resources in Europe. The structure and programmatic goals outlined in this issue are intended to provide a framework for understanding the growth and influence of European Community research programs. The articles discuss the future of European science and technology in light of the programs of the EC, the Single European Act, and the potential of a Europe Without Frontiers by the end of 1992.</p>			
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Europe 1992

The View from the Office of Naval Research European Office

by Dr. James E. Andrews, ONREUR Scientific Director

The structure and programmatic goals outlined in this issue of the European Science Notes Information Bulletin are intended to provide a framework for understanding the growth and influence of European Community (EC) research programs. The articles discuss the future of European science and technology (S&T) in light of the programs of the EC, the Single European Act, and the potential of a *Europe Without Frontiers* by the end of 1992.

The EC's goals for 1992 and the Single European Act have nothing explicitly to do with research and development (R&D). They are political goals focused on commercial and trade barriers, including the development of common or interchangeable licensing and professional standards, and the easing of cross-border movement of people, goods, and ideas. However, the processes to achieve these ends (by December 1992) that are in place and are planned are having a major philosophical effect on scientific planning. Through the growing leverage of EC-funded R&D programs, these processes are moving European science toward stronger internal ties and internally focused growth.

The implications of 1992 and these rapidly changing perspectives are of major interest to the U.S. scientific community for their effect on future scientific interactions. The EC programs, such as Stimulation des Coopérations Internationales et des Echanges Nécessaires aux Chercheurs en Europe (SCIENCE), have specific components to encourage cooperative programs through funding intra-European travel and supporting postdocs and graduate students. Colleagues tell us that it is relatively easy to find resources for creating working groups and planning teams on an intra-European basis. Students can be more easily employed, and where postdocs were rare because of local labor laws, they are now becoming a way of life. In some countries and some disciplines, the influence of growing EC research support is resulting in decreasing allocations of national resources. In the U.K., this is the case in biotechnology. Because most European academic systems provide full support for salaries and basic infrastructure at the home institution, the application of EC funding can have a far larger influence than comparable funding in the U.S. soft money system.

Initial reactions to the bureaucracy of the EC funding system left many investigators cold. And, indeed, the computer forms and standard information required is significantly greater than that encountered with the Office of Naval Research or the National Science Foundation. On the other hand, most EC grants are multiyear, and once mastered, the forms are somewhat repetitious. Thus, the burden is not prohibitive on an annual basis and amortized over a couple of proposals. The EC programs also add a burden of panels and committees to formulate, guide, and review the programs. One can be a constructive member of only so many research programs and so many planning groups. From the U.S. perspective, this may lead to colleagues being increasingly shackled with a new set of programs. Old relationships do not end overnight and there is no suggestion that EC research has any fortress-Europe mentality. But there are new opportunities available within Europe, and future planning of multi- and bilateral initiatives must clearly include Brussels-based EC officials as major players.

In addition, the recent events in Eastern Europe are redirecting thoughts and resources in Europe. Science, and particularly environmental issues, are high on all agendas. Elections of new governments in Eastern Europe in the near future will open the door to new R&D programs and will see many exciting agreements implemented. Another aspect of the changes flowing through Europe is the active marketing by the Soviet Union of its R&D capabilities. "Earth Mission 2000, a Soviet commercial blueprint for planet management," held in December 1989 in London is a prime example. The 1990's will be an exciting time in European science as well as in European politics.

The Evolution of "Europe 1992"

by Dean L. Mitchell, the Liaison Scientist for Solid-State Physics in Europe and the Middle East for the Office of Naval Research European Office.

Introduction

The present moves in Europe toward social, political, and economic integration of 12 nations into a single EC trace their roots to the Treaty of Paris in 1951, which approved the creation of a European Coal and Steel Community (ECSC). The success of the initial experiment in cooperative development led to the formation of the European Economic Community (EEC) by the signatories of the Treaty of Rome in 1957. The vision of a unified Europe was provided in the Treaty of Rome by its introductory words: "The Community shall have as its task, by establishing a common market and progressively approximating the economic policies of Member States, to promote throughout the Community a harmonious development of economic activities, a continuous and balanced expansion, an increase in stability, an accelerated raising of the standard of living and closer relations between the states belonging to it."

In the Single European Act (Act), signed in February 1986, the member nations approved the completion of these moves toward integration by pledging their commitment to the legislative processes necessary to create a single European market economy by the year 1992, hence "Europe 1992." The substance Act is summarized in article 8a which states, "The Community shall adopt measures with the aim of progressively establishing the internal market over a period expiring on 31 December 1992, in accordance with the provisions of this Article. The internal market shall comprise an area without internal frontiers in which the free movement of goods, persons, services, and capital is ensured in accordance with the provisions of this Treaty."

Composition and Governance

The EC, as presently constituted, is comprised of the 12 member nations--Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. The legislative functions of the EC are carried out by the European Parliament which meets in Strasbourg, France. The judicial functions are incorporated in the Court of Justice which meets in Luxembourg. The executive functions, which are the most varied and employ the largest bureaucracy, are vested in the European Commission (Commission) which is headed by 17 commissioners with at least one representative from each of the 12 member states. The commissioners, who serve 4-year terms, are pledged to act in the interests of the EC

and are expressly prohibited from taking instructions from home governments. The Commission, located in Brussels, Belgium, oversees the 22 Directorates General (DG) which provide the executive "civil service" for the community. The directorates are listed in Appendix B. Overall policy guidance to the EC is given by the Council of Ministers (Council), comprised of ministers from each of the member countries. The Council meets several times each year, usually in Brussels, a few times per year in Luxembourg, and occasionally at some other location. The Council is the policy-making body for the EC (in effect, a Board of Directors) and acts as a counterweight to the Commission. In executive matters, the Council is restricted to acting on proposals originated by the Commission and can only alter proposals with unanimous consent. Most decisions rely on majority approval which is defined by 54 votes out of the 76 assigned to the 12 member nations.

Market Integration

In 1987, the population of the member countries of the EC stood at 324 million versus 244 million for the U.S.; the comparable Gross Domestic Products (GDP) were \$3,720 billion for the EC and \$4,385 billion for the U.S. The \$11,500 per capita GDP for the EC is significantly lower than the U.S. figure of \$18,000 partially caused by the lower-than-average figures for Greece, Ireland, and Portugal. These comparisons indicate that the EC has the potential for creating a market economy that would be comparable with that of the U.S. or Japan.

Significant progress has been made toward the goals set in the Act. As of June 1989, roughly the half-way mark, the Commission had made formal proposals on 234 of the 279 legislative directives required for "Europe 1992;" 130 have been adopted and are now being implemented. However, the EC is still, for the most part, a collection of 12 separate and rather small markets with disparate regulatory systems and quite different national practices for law, medicine, banking, and marketing. The separate countries are attempting to harmonize their laws and regulations so that the present boundaries to commerce, jobs, and education will be removed or reduced and allow free exchange among the member countries.

Budget

Almost all of the budget for the EC governmental operations is provided by a tax on the value added tax

(VAT) collected by each country--up to a 1.4 percent maximum. In 1985, this provided a total income to the EC of 28,400 million ECU (European Currency Unit, equal to \$1.15 for purposes of this article). Of this total budget of \$32,600 million, over 70 percent went to subsidies for agriculture and fisheries. Research, energy, industry, and transport funds totaled 2.6 percent.

Impact on Research and Development

Although the main forces driving the move toward a single EC market in 1992 are economic and agricultural, the impetus to improve market positions through cooperative R&D is becoming increasingly important. On a very basic level, the integration will require efforts to develop common industrial standards and compatible tax policies for industrial R&D, as well as direct support of R&D projects per se. The stated aim of the EC-supported research is to develop marketable new technologies or to make mature technologies more competitive.

The EC recently published a 5-year "Framework Program for Research and Technological Development" covering 1987-1991. This provides the guidance for the development of research programs during this period. A synopsis of the program is presented here; a more complete coverage is given in a subsequent article. The total funding of 6,500 million ECU (\$7,500 million) over 1987-1991 (see Table 1 and article on page 7 of this issue).

Table 1. Framework Program Funding

- Information Technologies, Telecommunications, and Transport - 42%
- Nuclear and Non-Nuclear Energy - 22%
- Industrial Technologies, including Advanced Materials - 16%
- Health and Environment - 7%
- European Cooperation in Science and Technology - 5%
- Biotechnology and Agro-Industrial Technologies - 5%
- Other, including Fisheries and Marine Science - 3%

Institutionally, 8 percent of the funds will support projects in government, industrial, and university laboratories in the member states; 13 percent will go toward support of the EC Joint Research Centers; 3 percent will be Concerted Action Programs among the member states in which the EC coordinates while other sources provide major funds.

Other European Research Organizations

In addition to its role in coordinating and supporting collaborative research projects among its members, the EC also participates in other pan-European research

projects originating from the European Science Foundation (ESF) which has a membership of 27 European governments and scientific associations as well as European Research Coordination Agency (EUREKA). The EUREKA is an organization of 19 nonaligned European countries (instigated by Francois Mitterand) to sponsor joint ventures among industrial consortia to develop marketable new technologies.

The ESF has a very limited budget (\$2.5 million) and mainly initiates and coordinates pan-European projects rather than providing research funds directly. Perhaps its most successful venture has been the sponsorship of the European Synchrotron Radiation Facility (ESRF) which presently is under construction in Grenoble, France, with construction and operating funds provided by 10 countries, not all of whom belong to the EC.

The most visible and successful EUREKA program is the Joint European Submicron Silicon Initiative (JESSI) which was formed in 1989 by a partnership of Siemens, Philips, and SGS-Thomson with a goal of capturing a share of the world market for silicon chips about equal to its own uses by 1994. A total of \$6,200 million has been allocated to this project with the costs split equally between the industrial partners and the member nations. The EC participates in JESSI on the same basis as a member nation.

EC Research Programs

The EC has evolved into a major source for research support in Europe. The absolute level of funding is small, on the order of 5 percent, compared with the funding provided by national programs. However, the EC provides a larger influence than raw numbers would indicate. First and most important, the EC funds generally require collaboration among researchers in different countries and laboratories, often with industrial participation. This is a major force for breaking down specialization boundaries in Europe and for fostering more interdisciplinary interaction. Second, many European laboratories, particularly in universities, have institutional support for professorial and student salaries but lack money for equipment and operating expenses. The EC projects gain leverage for directed research in such laboratories by providing relatively small grants covering equipment, supplies, and travel.

The Commission has developed a sophisticated research management system in Brussels which has adopted all of the research management methods used by U.S. research funding agencies including proposals, peer review, and wide use of scientific advisory panels to recommend on policy and funding priorities. Complaints are very common about the level of bureaucratic complexity and delays in actually receiving funds following project approval. The saving grace for EC-supported

research is that the funds generally cover the full lifetime of the projects, typically 2-4 years.

Several DG have the main responsibility for funding the R&D projects supported by the EC. These are the DG for Agriculture (VI); Environment Consumer Protection and Nuclear Safety (XI); Science and Research (XII); Telecommunications, Information Industries, and Innovation (XIII); and Fisheries (XIV). The programs listed below are funded by these directorates with almost all coming from XII and XIII. A description of the programs and the funding is given in the Framework Program article. A summary of some of the higher visibility programs is given here.

The European Strategic Programme for Research and Development in Information Technologies (ESPRIT) is the most visible and most successful of the EC programs. The ESPRIT supports a broad range of collaborative research programs spanning the range from applied mathematics to materials processing in semiconductors. A 5-year extension, ESPRIT II, has been approved at 1,600 million ECU (\$1,850 million) for the 5-year period 1988-1992. With matching funds, the \$3,700 million program will support 30 percent of the precompetitive research in Europe in information technology.

The SCIENCE program, formerly called the STIMULATION program, was initiated in order to promote mobility and collaborative interaction among researchers in different EC countries. The 5-year budget for travel, research, and coupling grants is 167 million ECU (\$190 million). The availability of funds for travel and scientific exchanges is particularly advantageous since funds for these purposes are difficult to obtain otherwise. Other EC programs supporting research are provided in Table 2.

How the moves toward "Europe 1992" will influence the infra-structure and conduct of research in Western Europe is still too early to predict. The direction that the evolution takes in Europe has become even more uncertain in 1989 with the movements toward national independence in Eastern Europe.

On page 23, G. Patrick Johnson, European National Science Foundation representative, Paris, presents a summary of the "First Report on the State of Science and Technology in Europe" prepared for the Council. This report gives a European perspective on competitive positions in research and technology vis a vis the U.S. and Japan. This follows Dr. Marco Di Capua's article on the EC's Framework Program. In subsequent articles, aspects of the impact of "Europe 1992" on individual disciplines are provided by the liaison staff of ONREUR. While the coverage is not complete, it does provide some valuable vignettes of research in Europe, half-way to "Europe 1992."

Table 2. EC-Supported Research Programs

Research in Advanced Communications in Europe (RACE) - 550 million ECU (\$660 million) - 1987-1992
BRITE II/EURAM II which combines the initiatives in Basic Research in Industrial Technologies in Europe (BRITE) and European Research in Advanced Materials (EURAM) - combined program total of 500 million ECU (\$600 million) - 1989-1992
Agri-Industrial Research - 160 million ECU (\$192 million) - 1989-1993
JOULE (Research on Non-Nuclear Energy Sources) - 122 million ECU (\$145 million) - 1985-1988
Environmental Research - 75 million ECU (\$90 million) - 1986-1990
Biotechnology Action Program (BAP) - 75 million ECU (\$90 million) - 1985-1989
Road Transport Technology - 60 million ECU (\$72 million) - 1989-1992
Applied Metrology and Chemical Analysis (standards) - 60 million ECU (\$72 million) - 1988-1992
Research in Marine Science And Technology (MAST) - 50 million ECU (\$60 million) - 1989-1992
Support Promoting Individual Access to Large-Scale Research Facilities - 30 million ECU (\$36 million) - 1988-1992
R&D Analyzing and Forecasting - 22 million ECU (\$26 million) - 1988-1992
Other relatively small research-related programs in education, medicine, space, and nuclear safety.

The European Community Framework Program

by Marco S. Di Capua, the Liaison Scientist for Physics in the Office of Naval Research European Office. Dr. Di Capua is an experimental physicist on leave from the Lawrence Livermore National Laboratory, University of California.

Introduction

Present EC funding for R&D and S&T comes through the 1987-1991 Framework program. Title VI (Articles 130f to 130q) of the Single European Act (Act), adopted in February 1986, provides the legal basis for EC activities in the field of R&D and S&T. In particular, Article 130f states the aim of the EC to strengthen the scientific and technological basis of European industry encouraging industry to become more competitive at the international level. On the basis of Article 130i, the EC funds R&D activities within a multiannual Framework program. At present, research is the third largest area of EC spending after farming and regional development aid.

The initial Framework program covered the period 1984-1987. A Framework program for the 1987-1991 was adopted in October of 1987 and, in view of 1992, a new Framework program that will have activities in common with the current 1987-1991 Framework program, is being adopted for the 1990-1994. In ESNIB 88-08:2-4 (an issue that profiled S&T issues in Europe as viewed from the perspective of U.S. Embassies and Missions), P. Haigh discussed the relationship of the Framework program to the 1992 single European market. This ESNIB article

- Provides a brief description of the management, funding approaches, and budgets (see Table 3) of the 1987-1991 Framework program
- Shows how the components of the program fit together, provides a background for the ever-increasing number of mnemonic acronyms that sprout in Brussels, and shows the levels and modes of funding
- Summarizes the recommendations of the Framework Program Review Board report of June 1989
- Overviews the 1990-1994 program, discusses the present funding negotiations and displays the most recent budget (see Table 4).

Table 3. Current Framework Program Budgets (1987-91)

	MILLION ECU	\$	%
A Quality of Life			
1. Health	80		
2. Radiation protection	34		
3. Environment	261		
TOTAL	375	450	6.9
B Towards a Large Market and as Information and Communications Society			
1. Information technologies	1600		
2. Telecommunications	500		
3. New services of common interest (including transport)	125		
TOTAL	2275	2730	42.3
C Modernization of Industrial Sectors			
1. S&T for manufacturing industry	400		
2. S&T of advanced materials	220		
3. Raw materials and recycling	45		
4. Technical standards, measurement methods, and reference materials	180		
TOTAL	845	1014	15.6
D Exploitation and Optimum Use of Biological Resources			
1. Biotechnology	120		
2. Agro-industrial technologies	105		
3. Competitiveness of agriculture and management of agricultural resources	55		
TOTAL	280	336	5.2
E Energy			
1. Fission: nuclear safety	440		
2. Controlled thermonuclear fusion	611		
3. Non-nuclear energies and rational use of energy	122		
TOTAL	1173	1408	21.7
F S&T for Development	80		1.5
G Exploitation of the Seabed and Use of Marine Resources			
1. Marine science and technology	50		
2. Fisheries	30		
TOTAL	80	96	1.5
H Improvement of European S&T Cooperation			
1. Stimulation, enhancement and use of human resources	180		
2. Use of major installations	30		
3. Forecasting and assessment and other back-up measures (including statistics)	23		
4. Dissemination and utilization of S&T research results	55		
TOTAL	288	345	5.3
GRAND TOTAL	5396	6475	100

Table 4. EC Framework Budget 1990-1994¹
(million EUC)

As approved by Council of Research Ministers
on 15 December 1989

Theme	90-94 Funding
Enabling technologies	2221
Information technologies	(1352)
Communications technologies	(489)
Telematic systems development	(380)
Industrial and materials technologies	888
Environment	518
Biosciences and biotechnology	741
Energy	841
Non-Nuclear	(157)
Nuclear fission safety and support	(199)
Nuclear fusion	(458)
Human capital and mobility	518
Total	5700

(Totals include funds for administration and to JRC, Ispra.)

Framework Program Management and Funding Approaches

Management. As part of the executive branch of the EC, the European Commission, through a number of DG (see article on page 3 and Appendix B), manages the EC research activities that are carried out within the scope of the Framework Program. The DGs are:

DG VI: Agriculture

DG XII: Science and Research (which includes overall S&T policy)

DG XIII: Telecommunications, Information Industries, and Innovation

DG XIV: Fisheries

Framework Program Funding Approaches². Funding of the Framework program components takes place in three principal modes:

1. **Shared Cost Contracts.** These are the principal instruments for EC research funding with EC contribution a fraction (usually one-half) of the project cost. Research may be performed at establishments of higher education; e.g., universities, public research institutes, and private companies. The EC welcomes consortia of companies and educational institutions.
2. **Concerted Actions.** The EC determines the priorities and work plans while EC member states fund

¹The narrative on page 7, the monies in Table 3, and the budget on page 8 are not always consistent.

²Any European budgets discussed below should be multiplied by factors between two and three to translate them to U.S. equivalents. The reason is because permanent university and laboratory staffs are paid from institutional funds and therefore do not charge salaries against project funds. Consequently, a European \$160 million facility is equivalent to a U.S. \$400 million plus facility.

the research. The EC coordinates the work and stimulates the exchange of research results.

3. **Training Activities.** The EC stimulates university/industry cooperation to improve high-level training linked to new technologies and encourage the mobility of students in higher education, adding a European dimension to their initial training.

1987-1991 Framework Program Components

A. Quality of Life

Medical and Health Research (DG XII). The objective is to increase the scientific and economic efficiency of medical research efforts in member states through their gradual coordination at Community level, and to optimize the capacity and economic efficiency of health-care efforts throughout the Community. The program focuses on four major health issues: (1) cancer, (2) AIDS, (3) age-related health problems, (4) environmental and life-style related problems; and two health resource areas: (1) medical technology development and (2) health services research [Community budget: 65 million ECU, Program duration: 1987-1991, Type of operation: Concerted action].

Radiation Protection (DG XII). The objective is the efficient and cost-effective protection of human beings and their environment from ionizing radiation and radioactivity. The main program themes are human exposure (assessment, prevention, and treatment), and the risks and management of radiation protection [Community budget: 21.2 million ECU, Program duration: 1990-1991, Type of operation: Shared-cost contracts].

Human Genome Analysis (DG XII) (under consideration). The objective is to encourage the development of advanced genetic technologies to study the human genome, to improve the resolution of the human genetic map, and to establish an ordered clone library of human DNA [Community budget: 15 million ECU, Program duration: 1989-1991, Type of operation: Shared-cost contracts, concerted actions, and training grants].

Environment (DG XII). The environmental programs comprise the protection of the environment (55 million ECU), climatology and natural hazards (17 million ECU), and pilot projects on major technological hazards (3 million ECU). The environmental research program covers health and ecological effects of pollutants; assessment of chemicals; air, water, and soil quality; noise, ecosystem, and waste research; and pollution reduction. The climatology and natural hazards program concentrates on the physical basis of climate, climate sensitivity, climatic impacts, seismic risk evaluation and causes, mechanisms and impacts of climatological anomalies, and extreme or abrupt events [Community budget: 75 million ECU, Program duration: 1986-1990, Type of

operation: Shared-cost contracts, concerted actions and training activities].

Proposed Framework Follow-on Activities. Science and Technology for Environmental Protection (STEP) will comprise research into environment and human health, risks associated with chemicals, air and water quality, soil and ground-water protection, ecosystems, protection of European cultural heritage, environmental protection technologies, major technological hazards, and fire safety. European Program on Climatology and Natural Hazards (EPOCH) will comprise research into past climates and climate change, climate processes and models, climatic impacts and climate-related hazards, and seismic hazards [Community budget: STEP - 75 million ECU, EPOCH - 40 million ECU, Program duration: 1989-1992].

B. Towards a Large Market and an Information and Communications Society

ESPRIT II (DG XIII). Adopted in 1984, European Strategic Programme for Research and Development in Information Technologies (ESPRIT) was conceived for a 10-year period with three main objectives: (1) to help provide European IT industry with the technology base needed to meet the competitive requirements of the 1990s, (2) to promote European industrial cooperation in IT, and (3) to contribute to developing internationally accepted standards.

For the second phase of ESPRIT (ESPRIT II), the sectors for support have been adapted to the rapid pace of technological development and consolidated into three sectors: (1) Microelectronics and Peripherals, (2) Information Processing Systems, and (3) IT Application Technologies. New emphasis is being placed on strengthening European capabilities in such areas as Application-Specific Integrated Circuits (ASIC), high-performance parallel processing computers and new office workstations, while ESPRIT II also includes a new component, Basic Research Actions, designed to complement the main industrial program [Community budget: 1600 million ECU, Program duration: 1988-1992, Type of operation: Shared-cost contracts].

RACE (DG XIII). The RACE deals with the Integrated Broadband Communications (IBC) of the future. The program is designed to lay the foundations of the Community's communications infrastructure for the 1990s and into the 21st century, by combining the expertise of telecommunications researchers, manufacturers, administrations, and broadcasting stations across European frontiers. The program covers IBC development and implementation strategies, IBC technologies and prenormative functional integration [Community budget: 550 million ECU, Program duration: June 1987 - May 1992, Type of operation: Shared-cost contracts].

DELTA (DG XIII). Development of European Learning through Technological Advance (DELTA) is designed to support the R&D required to enable the emerging technologies to be utilized for the benefit of teaching and learning. The devices and techniques to be addressed include: more powerful processors including image processing; larger and cheaper storage, with new techniques of data organization; Direct Broadcasting by Satellite; the Integrated Services Digital Network (ISDN); artificial intelligence; access by near-natural language and, in the more distant future, switched broadband communications and fifth generation systems with voice access [Community budget: 20 million ECU, Program duration: 24 months starting March 1989, Type of operation: Shared-cost contracts].

DRIVE (DG XIII). Dedicated Road Infrastructure for Vehicle Safety in Europe (DRIVE) is designed to create the conditions for an integrated road transport environment in IT, and telecommunications applied to road transport (see *ESNIB* 89-01:48-49). The program includes RTI technologies, evaluation of strategic options and specifications, protocols, and standardization proposals [Community budget: 60 million ECU, Program duration: 36 months starting January 1989, Type of operation: Shared-cost contracts].

AIM (DG XIII). Advanced Informatics in Medicine (AIM) deals with the application of IT to medical science and health care. The objective is to sustain quality growth in health care in the Community for the 1990s within economically acceptable limits by exploiting the potential of Medical and Bio-Informatics (MBI) [Community budget: 20 million ECU, Program duration: 24 months starting mid 1989, Type of operation: Shared-cost contracts].

C. Modernization of Industrial Sectors

BRITE/EURAM (DG XII). This new single BRITE/EURAM program builds on the experience and the achievements already emerging in the first BRITE and EURAM programs, and will cover cost-shared research projects concerning advanced materials technologies, design methodology and assurance for products and processes, application of manufacturing technologies, and technologies for manufacturing processes. The program will also carry out research aimed at developing the European aeronautical technology base, including aerodynamics, acoustics, airborne systems, and equipment and propulsion systems. The program will include coordinated activities and feasibility awards aimed at assisting Small Manufacturing Entities (SME). A separate research program in aeronautics will be prepared to follow this pilot phase [Community budget: 499.5 million ECU, Program duration: 1989-1992, Type of operation: Shared-cost contracts].

BCR (DG XII). Community Bureau of Reference (BCR) is responsible for an R&D program in applied

metrology and chemical analysis. The program aims to improve measurements, chemical analyses, and testing in: (1) preregulation work in agriculture and environment, and technical support to the application of Community Directives; (2) prestandardization in testing industrial products and support to harmonizing standards and their application; (3) improvement of measurements for the industrial requirements of high technologies; e.g., automatic manufacturing, electronics, advanced optics, and laser applications [Community budget: 59.2 million ECU, Program duration: 1988-1992, Type of operation: Mainly shared-cost contracts].

Raw Materials and Recycling (DG XII). This program aims to help enhance the international competitive position of the Community's industries involved with raw materials and recycling. The program will include primary raw materials, recycling nonferrous and strategic metals, renewable raw materials (forestry and wood products), and recycling waste [Community budget: 45 million ECU, Program duration: 1990-1992, Type of operation: Shared-cost contracts].

D. The Exploitation and Optimum Use of Biological Resource

Biotechnology (DG XII). The aim of the BAP is to develop the Community's capacity to master and exploit the applications of modern biology to agriculture and industry. The program includes activities of research, training, and concertation in the key areas of biotechnology. The program also covers contextual measures for R&D in biotechnology; e.g., bioinformatics, collections of biotic materials; basic biotechnology; e.g., enzyme engineering, genetic engineering, technology of cells and tissues cultured in vitro, and concertation activities [Community budget: 75 million ECU, Program duration: 1985-1989, Type of operation: Shared-cost contracts and training grants].

Proposed Follow-on Activities. Biotechnology Research for Innovation, Development, and Growth in Europe (BRIDGE) will continue the work of BAP in strengthening the scientific base of Europe's biotechnology, and hence improve its international competitiveness. The program will include research and training activities (90 percent) and concertation activities (10 percent). The research and training program will include information infrastructures (culture collections, data processing), enabling technologies (protein design, molecular modeling, gene mapping, biotransformation), cellular biology and prenormative research; e.g., safety assessments and evaluation of toxicity.

Concertation will cover a range of monitoring, information, and collaborative activities to provide and facilitate the effective application of biotechnology to the Community's social and economic objectives [Community budget: 100 million ECU, Program duration:

1990-1994, Type of operation: Shared-cost contracts, training awards and studies].

ECLAIR (DG XII). The objective of the European Collaborative Linkage of Agriculture and Industry through Research (ECLAIR) program is to promote in Europe the useful application of recent developments in the life sciences and biotechnology. The program will consist of production and evaluation trials of candidate species or organisms, industrial products and services, and integrated approaches [Community budget: 80 million ECU, Program duration: 1988-1993, Type of operation: Shared-cost contracts, concerted actions, and training/mobility awards].

FLAIR (DG XII). The proposed Food Linked Agro-Industrial Research (FLAIR) program will focus on the interface between consumer, industry and research, concentrating on the downstream end of food S&T, and coordinating research and industry efforts with the consumer's demands and requirements. The program will be comprised of three sections: (1) measurement and enhancement of food quality; (2) food hygiene, safety, and toxicology aspects; and (3) nutrition and wholesome aspects [Community budget: 25 million ECU, Program duration: 1989-1993, Type of operation: Shared-cost contracts and concerted actions].

Agricultural Research (DG VI) (under consideration). The aim of this program will be to help EC farmers to adapt to the new situation created by overproduction and the restrictive prices and markets policy, to improve farming conditions in regions that have been slow to develop, to encourage environmental protection and land conservation, to develop agricultural information services, and to improve the dissemination of research results [Community budget: 55 million ECU, Program duration: 1989-1993, Type of operation: Shared-cost contracts, pilot projects, and coordination activities].

E. Energy

Radioactive Waste (DG XII). The program is aimed at perfecting and demonstrating a system for managing the radioactive waste produced by the nuclear industry, ensuring at the various stages the best possible protection of human beings and the environment. The program covers waste management studies and associated R&D actions and construction and/or operation of underground facilities open to Community joint activities. A new program (1990-1994) is being prepared (79.6 million ECU) [Community budget: 62 million ECU, Program duration: 1985-1989, Type of operation: Shared-cost contract].

Decommissioning of Nuclear Installations (DG XII). The aim of the program is the joint development of a system to manage the shutdown of nuclear installations and the radioactive wastes produced in their dismantling.

At its various stages, this program will provide human beings and the environment with the best protection possible. The program covers R&D projects, the identification of guiding principles and the testing of new techniques under real conditions within the framework of large-scale decommissioning operations undertaken in members [Community budget: 31.5 million ECU, Program duration: 1989-1993, Type of operation: Shared-cost contract].

TELEMAN (DG XII). The Telemanipulator Research Program (TELEMAN) is a 5-year research program covering remote handling in the nuclear industry, hazardous, and disordered environments. The technical objective is to strengthen the scientific and engineering bases for the design of teleoperators for the nuclear industry. This will be done by providing new solutions to problems of manipulation, material transport, mobile surveillance in nuclear environments, and by demonstrating their feasibility [Community budget: 19 million ECU, Program duration: 1989-1993, Type of operation: Shared-cost contracts].

Controlled Thermonuclear Fusion (DG XII). Controlled thermonuclear fusion potentially can provide a major new source of energy for the next century that possibly has a limited impact on the environment and which would use primary fuels that are abundant in the Community. All European fusion research is integrated into one Community program whose objective is to lead in due course to the joint construction of prototype reactors with a view to their industrial production and marketing [Community budget: Joint European Torus (JET) and General program 735 million ECU, Fusion technology and safety 60 million ECU, Program duration: 1988-1992, Type of operation: The program is executed principally through a network of associations with national organizations (usually one per country) and through the JET joint undertaking, as well as through the Next European Torus (NET) project and the Joint Research Centers (JRC)].

JOULE (DG XII). The Joint Opportunities for Unconventional or Long-Term Energy Supply (JOULE) program will ensure continuity with the previous non-nuclear energy program (1985-1988), but with an updated form and content so that it can pursue earlier promising developments and attain the current objectives. The four subprograms of JOULE will focus on (1) models for energy and environment, (2) rational use of energy (energy conservation and storage), (3) energy from fossil sources (hydrocarbons and solid fuel), and (4) renewable (wind, photovoltaic, hydraulic, and biomass) and geothermal energy. The program will consist of activities carried out by means of shared-cost research and study contracts, coordination projects, and awards of training and mobility grants [Community budget: 122 million ECU, Program duration: 1989-1992, Type of operation:

Shared-cost contracts, concerted actions, and training/mobility grants].

STD (DG XII). The Science and Technology for Development (STD) program aims at promoting an increased scientific cooperation between the EC and developing countries to their mutual benefit and is comprised of two subprograms. The tropical and subtropical agriculture subprogram (55 million ECU) covers the improvement of agricultural products, conservation, and better use of the environment, agricultural engineering, and postharvest technology and production systems. The second subprogram (25 million ECU) concerns medicine, health, and nutrition in tropical and subtropical areas [Community budget: 80 million ECU, Program duration: 1987-1991, Type of operation: Mainly shared-cost contracts].

F. Exploitation of the Sea Bed and Use of Marine Resources

MAST (DG XII). The main focus of the Marine Science and Technology (MAST) program will be on coastal and regional seas, but this does not exclude some limited research on the open sea where particularly relevant. The program will cover basic and applied marine science (modeling and oceanography), coastal zone science and engineering, marine technology and supporting initiatives (in particular, the need for better use of existing facilities, improved training, and sharing data and information) [Community budget: 50 million ECU, Program duration: 1989-1992, Type of operation: Shared-cost contracts and concerted actions].

FISHERIES (DG XIV). The research and coordination programs cover the fields of fishery management, fishing methods, aquaculture, and upgrading of fishery products [Community budget: 30 million ECU, Program duration: 1988-1992, Type of operation: Shared-cost contracts and concerted actions].

G. European Scientific and Technical Cooperation

SCIENCE (DG XII). The SCIENCE consists of a range of activities selected on the basis of their scientific and technical quality, whose aim is to establish a network of scientific and technical cooperation and interchange at a European level. The SCIENCE aims to improve the efficacy of research in member states and to help reduce the scientific and technical disparities among them. The program covers all fields of the exact and natural sciences; e.g., mathematics, physics, chemistry, life sciences, earth and ocean sciences, scientific instrumentation, and engineering sciences [Community budget: 167 million ECU, Program duration: 1988-1992, Type of operation: Bursaries, research allocations, grants for high-level courses encouraging the twinning of laboratories, and operations contracts]. Another section in this issue discusses SCIENCE in more detail.

SPES (DG XII). The Stimulation Plan for Economic Science (SPES) program consists of a range of activities to establish a network of cooperation and interchange between economists of the highest professional quality at the European level. Possible research topics are issues related to the internal market of the Community, European integration economics, economic growth in Western Europe, systematic issues in the monetary areas and macroeconomic and fiscal policy coordination, trade policy, the role of Western Europe in the international division of labor and employment, and social policy issues [Community budget: 6 million ECU, Program duration: 1989-1992, Type of operation: Scholarships, research grants, and subsidies for training courses and scientific meetings].

Large-Scale Scientific Facilities (DG XII). The program consists of a range of temporary financial support arrangements granted to scientific institutions in the Community having large-scale R&D facilities or installations. They, in return for the Community contribution, agree to make these facilities or installations available to scientists and researchers working in universities, public research contract, or industrial laboratories. Researchers and scientists to whom facilities and installations have been made available will be able to benefit from research grants and funds provided for in the SCIENCE plan. The program covers all fields of the exact and natural sciences, research, and precompetitive technological development [Community budget: 30 million ECU, Program duration: 1988-1992, Type of operation: Shared-cost contracts and grants].

MONITOR (DG XII). The MONITOR program's purpose is to contribute to the identification of new directions and priorities in the common research and technological development policy, to establish more clearly the relationships between it and the other common policies, and to improve evaluation of R&D programs. The program is comprised of three activities: (1) Strategic Analyses in the Field of Science and Technology (SAST), (2) Forecasting and Assessment in Science and Technology (FAST), and (3) Support Program for the Evaluation Activities in the Field of Research (SPEAR).

The SAST activities consist of impact studies (technological, industrial, socioeconomic, environmental) and analyses targeted at a scientific field, technology, or sector. The FAST activities include studying scientific and technological changes and their many interactions with economic and social changes. The SPEAR activities concern the definition of practical and reliable procedures for the evaluation of R&D programs and other methods of carrying out R&D. They also cover the means of support and management of research [Community bud-

get: 22 million ECU, Program duration: 1988-1992, Type of operation: Contracts and grants].

DOSES. The Development of Statistical Expert Systems (DOSES) aims at enhanced capacity to produce and use statistical information, employing advanced data processing techniques. The actions address the exploitation of advanced ITs in the field of statistics, in particular the application of expert systems technology to the whole chain of statistical data processing. The actions develop knowledge and expert systems rules, which can constitute the base for the development of expert systems in various domains of the statistics field.

The program will consist of two parts: Part I comprises the organization of coordinated projects, and Part II comprises R&D projects jointly funded and regarded as meriting priority in the field of official statistics [Community budget: 4 million ECU, Program duration: 1989-1992, Type of operation: Shared-cost contracts and concerted actions].

VALUE (DG XIII). The purpose of Valorization and Utilization for Europe (VALUE) is to ease and accelerate the circulation of information related to Research and Technology Development (RTD) work and results to increase the efficiency of the RTD work itself. The program will also stimulate the process of innovation and industrial exploitation in Europe by facilitating, through general measures, utilizing results of Community RTD by all potential users and by improving the efficiency of distributed R&D activities throughout Europe. The two subprograms cover the areas of dissemination and utilization of Community RTD results and computer communication networks [Community budget: 38 million ECU, Program duration: mid 1988-mid 1992, Type of operation: Subsidies, service, and shared-cost contracts and studies].

EUROTRA (DG XIII). European Translation Program (EUROTRA) is a cost-shared program aimed at creating a machine translation system of advanced design, capable of dealing with all official languages of the Community. The proposed European Council of Research Ministers decisions concern the transfer of the EUROTRA program to its third phase (stabilization of the linguistic models and evaluation of results) and a specific program for the completion of a machine translation system of advanced design. The objective of the specific program (6.5 million ECU) is executing the supplementary tasks required in the third phase of EUROTRA (inclusion of Spain and Portugal) and the reinforcement of software development and preparation for industrial involvement [Community budget: 27 million ECU, Program duration: 1989-1990, Type of operation: Shared-cost contracts and concerted actions].

June 1989 Framework Program Review

Fillipo-Maria Pandolfi³, new European Commissioner for Science, Research and Development, Telecommunications, and JRCs, asked the Framework Programme Review Board (Board) (P. Aigrain, France; G. Allen, U.K.; E. de Arantes e Oliveira, Portugal; U. Colombo, Italy; and H. Markl, Federal Republic of Germany [FRG]) to review the Framework program in the context of European evolution towards the 1992 goal. The Board issued its report on June 13, 1989, with recommendations in research criteria (see Table 5), program management (see Table 6), funding (see Table 7), development of the scientific humus (see Table 8), future directions of maturing programs (see Table 9), and dissemination of research results (see Table 10).

The Board also provided an assessment of specific programs and of the operation of the JRCs (see ESNIB 89-02:39).

Table 5. Research Criteria Recommendations

- Improve coordination of R&D activities sponsored by different DGs, abbreviate decision times, and preferentially fund programs where promotion through national and international mechanisms is deficient
- Concentrate on EC-funded research in areas that cannot be funded at the national level, generic technologies vital to Europe's industrial future, standardization that eases operation of the single market, programs that provide opportunities for training and information flow that will strengthen economic activities in the community
- Avoid replacement, duplication, or absorption of independently funded programs such as EUREKA, EMBO, CERN, ILL, COST, ESA, and ESF
- Place a special emphasis on research leading to agriculture as a source of raw materials and renewable energy supplies and keep well in sight new approaches to waste management
- Facilitate the access of small and medium enterprises to advanced R&D
- Inject advanced technologies to rejuvenate Europe's traditional and mature industries.

Table 6. Program Management Recommendations

- Establish a structure for the Framework program that reduces the number of line items in the program to increase funding flexibility so programs can be modified according to changing needs. The main program components should be:
 - S&T resource base that provides a fertile humus for growth of other knowledge
 - Research on quality of life and the environment involving health, natural and technological hazards, safety standards, and waste technologies; this aspect should link to global research programs
 - Continued strengthening of the technological base to enhance European competitiveness
 - Natural resource development and management embracing the biological sciences, agriculture, geological, and marine and deep sea resources
 - Provide a line for scientific services through:
 - A JRC that would deal with norms and standards, nuclear safety, industrial safety, risk analysis, and waste management
 - Technology assessment, technology forecasting, program evaluation and a European S&T data base.
- Integrate the needs of developing countries within the program
- Emphasize S&T push within DG XII and market pull and applications within DG XIII
- Encourage the Commissioner for R&D to provide political guidance to the DG to harmonize S&T policy within other EC policies
- Rotate program managers to prevent proprietorship attitudes that cloud judgement of program potential and foster perpetuation of completed or unpromising programs
- Speed up the selection process while maintaining high standards, and improve program definition to reduce confusion among applicants. One option is a two-tier application system where successful simple proposals lead to a competition between more detailed submissions. Another is to provide, through a reserve fund that is part of the budget, for short-term flexibility of funding at a time of rapid scientific change.

Table 7. Funding Recommendations

- Increase the fraction of the EC budget devoted to the S&T R&D effort to ensure European competitiveness
- Improve the flexibility of funding by incorporating reserves in the budget and incorporating mid-program reviews in 5-year funding cycles
- Increase budget allocations to VALUE and Advisory Committee on Research and Development (CORDI) (Advisory Committee on R&D) to accelerate the diffusion of EC sponsored research results
- Explore the use of venture capital to channel third party funds into research programs and into commercialization of R&D results.

³One of 17 appointed Commissioners in charge of the DGs.

Table 8. Development of the Scientific Humus Recommendations

- Reinforce the EC role in scientific and technical training by encouraging communication and exchange of information between European scientists through networking of institutions, teams, and individual experts
- Strengthen centers of excellence, encouraging them to expand training opportunities
- Generate centers of excellence to tap under-utilized talent in peripheral and less-developed areas of the community
- Target R&D and S&T support to foster, in EC scientists, a sense of belonging to a cohesive, attractive, and creative academic community by expanding the involvement of Europe's universities in activities of the Framework program. This support must coordinate with DG V activities regarding easing academic mobility, and promoting freer access to laboratories, networks, and data bases
- Expand funding for bursars in SCIENCE, a program that represents excellent value as an investment in European Science and the future of Europe.
- Interface the Framework program with training programs such as ERASMUS (which increases mobility of students in higher education in the Community) to add a European dimension to their initial training and COMETT (which stimulates university-industry cooperation in improving high-level training linked to new technologies).

Table 9. Future Directions of Maturing Programs Recommendations

- Emphasize collaboration between large companies and SMEs in the BRITE program, redirecting undersubscribed funding to materials' research of interest to the ESPRIT program
- Encourage industry to fund technology development in areas that are closer to market within the ESPRIT and BRITE/EURAM programs
- Require that industry take a greater participation in the direction and funding of the RACE program
- Encourage the EC to support a move to internationalize the Controlled Thermonuclear fusion Research (CTR) efforts. Participation in the International Tokamak Engineering Reactor (ITER) program is a step in the appropriate direction. The Board specifically recommends that the EC press for discussions with U.S., Japanese, and U.S.S.R. fusion teams to establish a global program in concert with the International Atomic Energy Agency (IAEA)
- Encourage the EC to restrict participation in the Joint European Submicron Silicon Initiative (JESSI), a part of the non-EC organization EUREKA, to basic and precompetitive aspects as the project approaches market.

Table 10. Dissemination of Research Results Recommendations

- The Board finds that the European policy of open door dissemination of research results is unparalleled and may be placing the EC at a competitive disadvantage. The Board recommends that precautions should be taken to uncontrolled diffusion of key information. The Board also recommends that the EC develop effective archival structures to collect, store, and retrieve data, as well as structures protection of intellectual property.

Assessments of Specific Programs

Assessments of specific programs, incorporated as an appendix of the Board report, may complement information that readers may obtain from other sources as well as Office of Naval Research European Office Reports provided in Table 11. An overview of the Board's assessments appears below.

Table 11. ONREUR Reports on European Programs

- ESPRIT
ESN 38-2:69-71 (1984)
ESN 38-5:248-252 (1984)
ESN 40-11-12:411-414 (1986)
ESNIB 89-03:13-17 (1989)
ONREUR Report 90-1-R (January 1990)
- RACE
ESN 39-3:122-123 (1985)
ONRL Report 8-014-R (August 1988)
ONREUR Report 9-7-C (March 1989)
ONREUR Report 9-13-R (January 1990)
- BRITE/EURAM
ONREUR Report 9-9-C (1989)
- EUREKA
ONRL Report 8-009-R (1988)
- DRIVE
ESNIB 88:08 (1988)

A. Quality of Life

The programs interact satisfactorily with national activities; they use the public infrastructure of the health system to good effect and make an important contribution to European cohesion. The EC programs on sequencing (Human Genome and Yeast) should aim at turning the EC into a credible partner to the U.S. and Japan in this global activity. Leading scientists in the Radiation Protection program are reaching retirement age so their ranks need to be replenished. Environmental programs must emphasize the development of a high-quality, reliable, common database to allow a better understanding of long-term environmental processes.

B. Towards a Large Market and an Information and Communications Society

The ESPRIT I, a highly precompetitive program with long-term links to the market, has broadened the European technology base in IT and fostered a spirit of co-operation among European firms. The ESPRIT II is still concerned with long-term applied research, also with market-driven, more focused Technical Integration Projects (TIP). The TIPs in progress are expected to significantly impact the competitiveness of European industry. The existence of TIPs allows EC participation in the JESSI program, eliminating wasteful overlaps. The small amount of funding (4 percent) allocated to basic research accelerates the training of scientists required for the success of the European IT industry. Forecasts show that in 1994, IT will be the single largest industrial sector in Europe, and two thirds of the other sectors will rely on IT for increased competitiveness. Therefore, in IT, long-term precompetitive areas, participation in TIPs, and precompetitive stages of the non-EC European Research Coordination Agency (EUREKA) program require expanded funding from ESPRIT.

Finally, the EC should satisfy the information exchange needs of European researchers. Such information exchange would benefit projects enormously, resulting in faster developments and lower costs. An important step would be to embrace, within the Framework program, an Information Exchange System; in the same spirit as the funding of ARPANET in the U.S. in the 1970s by the U.S. Advanced Research Projects Agency (ARPA).

In 1987, the main RACE program began to address the future of broadband communications systems within the EC. The RACE funding represents a very small fraction of the R&D expenditure in the telecommunications field in the EC. However, the involvement of private industry, government and telephone administrations in RACE, and the emphasis of the program in demonstration projects at the component, equipment, and systems levels provides RACE with a leverage that greatly exceeds its funding level. For this reason, external financing of program elements approaching maturity should free RACE resources to pursue new technologies that appear in the horizon.

The AIM, DRIVE, and DELTA programs are smaller. While AIM has been well received by the younger members of the medical community, the level of funding is probably too small to make a decisive impact. The DRIVE shares some common elements with the Programme for a European Traffic System with Highest Efficiency and Unprecedented Safety (PROMETHEUS) component of the EUREKA program (see *ESNIB* 89-01:48-49). A joint action may be required to increase the leverage of DRIVE funding. The DELTA program, which so far has concentrated on software issues, must

undertake research leading to hardware feasibility studies for educational work stations. Without such research, Japan or the U.S. are likely to become the sources of hardware for future educational systems in Europe, raising potential software compatibility issues.

C. Modernization of Industrial Sectors

The original BRITE program ran from 1985 through 1988; in March 1989, an updated BRITE merged with EURAM. According to the Board, the research goals of BRITE were insufficiently coordinated with requirements of the market, and research was performed in areas that did not exhibit the required technological or economical importance. According to the Board, BRITE is downstream of SCIENCE and upstream of Strategic Program for Innovation and Technology (SPRINT) managed, outside the Framework program, by DG XIII. In the future, the coordination of the programs should allow BRITE to exploit basic research results from SCIENCE. The expertise of SPRINT in the application of new technologies could allow an applications-oriented BRITE/EURAM program to identify priority areas, select relevant projects, and disseminate the results to European industry. Present indications are that BRITE/EURAM is moving in this direction.

D. Exploitation and Optimal Use of Biological Resources

According to the Board, the BAP-funded projects have been too limited in scale to acquire a European profile and to have a lasting impact. Community funding has been a welcome additional source of monies rather than an incentive to perform research in a European scale.

The BRIDGE program coming on line will concentrate on large, comprehensive, and ambitious projects emphasizing participation of the best research groups of the EC in large-scale, long-term projects. This program is an ideal home for genome mapping that requires technical competence in sequencing methods, computer networks for exchange, and access of sequencing information. The BRIDGE should also explore the consequences for man and the environment of the processes and products of genetic technology.

The ECLAIR (agro-industrial) and the FLAIR (food-technological) programs have had success in genetic analysis, crop improvement, development of new biological resources for consumption, and agricultural production of raw materials for industry. These activities may provide new market niches for agro-industry. The ECLAIR and FLAIR programs have been greatly oversubscribed, resulting in a high rate of proposal rejection causing frustration among researchers. The Board recommends fewer and larger actions involving the best contributors from the members, keeping in clear view economic

benefit and added value anticipated by transnational co-operation. The Board also recommends that some of the funding allocated to surplus production should be channeled into the Agricultural Research program funded by DG VI towards developing alternative crops and improving farming conditions in EC areas that have been slow to develop.

E. Energy

The **Framework** program funds EC energy research activities in fusion, nuclear safety, and rational use of energy/non-nuclear energy production. The shared goals of the program are: to reduce the vulnerability to disruptions in the petroleum supply, to assure the availability of energy at competitive prices, and to reduce the negative impact of energy production and consumption on the environment. To achieve these objectives, the EC has adopted programs on developing new energy sources, energy conservation, effectively exploiting domestic energy sources, improving technologies to reduce pollution, and increasing safety of nuclear installations.

Fusion. Controlled thermonuclear fusion could perhaps be considered the ultimate energy alternative. Since Europe perceives fusion as an important but long-term objective, all European fusion research is accomplished in association with the European Commission or directly under EC programs; e.g., JET and NET. The fusion programs are strongly coordinated, duplication is minimal, and there is a very high degree of collaboration, exchange of information, personnel, and equipment. As a result, the European program claims to be the most advanced in the world. In fusion, the Board makes four major recommendations to the EC:

1. Reconsider the role fusion will play in EC energy strategy. The vast investment necessary for NET must be defended at both the member government and European Parliament levels. These discussions will require an explicit regard of scenarios where fusion energy will play a pivotal role and an objective documentation of its advantages and difficulties of implementation.
2. Coordinate large projects such as ITER with the three countries that have large fusion programs--Japan, the U.S., and U.S.S.R.--to increase momentum and reduce individual expenditures arising from duplication of efforts.
3. Use the time between now and the construction of NET to perform an experiment designed to prove that energy breakeven can indeed be reached in a magnetic confinement configuration.
4. Re-examine the exclusion of inertial confinement fusion (ICF) from EC programs. This exclusion is a result of restrictions on information exchange arising from potential military applications of ICF. The Board

feels that changes in the international scene may now warrant such a re-examination.

Nuclear Safety. The **Framework** program sponsors minimal nuclear fission activities. There are developments funded by industrial and commercial concerns on thermal reactors; and in the fast breeder reactor area, European collaboration has remained outside the EC purview. Support from the **Framework** program concentrates on the safety aspects of nuclear energy. Good quality results from this effort have had a marginal impact in the energy picture. Since the Chernobyl experience, new priorities are emerging for nuclear research:

- Passively safe nuclear reactors
- Economically and environmentally acceptable decommissioning procedures for old and new installations
- Politically acceptable strategies for the reprocessing and long-term storage of radioactive wastes that minimize the risk of environmental contamination
- Clandestine diversion of fissile material.

Attitudes of the European governments on nuclear waste depend on their commitment to nuclear energy, so these areas are still maturing.

Rational Use of Energy and Non-Nuclear Energy Production. The commitment of the EC to non-nuclear energy research falls between the extremes of the Fusion and Fission programs. The EC-sponsored research has achieved substantial progress on photovoltaic energy conversion. The EC programs on geothermal energy have transferred Italian expertise on power generation and French expertise on space heating to other EC members, fostering EC cohesion.

The Board feels that indirect solar energy conversion through biomass deserves more effort. Biomass conversion would benefit the surplus-prone European agriculture by redirecting production towards new markets. This would benefit the agriculture of sunnier and less developed southern EC members, and biomass-based fuels would have a neutral impact on the carbon dioxide load of the atmosphere. Moreover, biomass agriculture can use brackish water, another advantage for sunnier and often drier environments. Advanced research would greatly contribute to the viability of this option that would result, in the long term, in lower subsidies to agriculture.

In energy conservation, EC funding has been small compared to the money spent in members' countries. However, the Board feels that leverage of EC funding has been substantial as a catalyst for cooperation and exchange of views. In some fields; e.g., fuel cells, EC limited its support to the most advanced and promising concepts. This excludes funding of fuel cell concepts that may become feasible in the medium term. Regarding fossil fuels, research performed by large industrial concerns, many of them multinational, greatly exceeds that spon-

sored by the EC. The JOULE program that began in mid-1989, will attempt to catalyze research in this area.

Production of hydrogen fuel through thermochemistry has received a great deal of attention from EC programs. However, studies show that thermochemical production lacks advantages over advanced electrolysis. The prospects of availability of excess electricity have reawakened interest on this approach. The Board recommends that the EC take a global and systems view of hydrogen as well as other energy vectors; e.g., methanol and coal/water slurries.

Energy demonstration has been a task of the energy directorate, DG XVII. The Board recommends that successful R&D sponsored by DG XII should result in a demonstration program sponsored by DG XVII. Finally, given the large fraction of external aid to global development programs devoted to the energy sector, the Board feels that EC research programs coordinate with research of interest to the developing world.

F. Marine Resources

Present funding of marine resource programs is far less than required to develop the enormous scientific and economic potential of this area. The Board feels that other programs such as climatology or environment also contribute to development of marine resources. The Board feels that MAST is too focused on the North Atlantic Ocean and some regional seas. Therefore, its coverage should be broadened to areas such as the West-central Atlantic Ocean which also has the key role in determining European weather.

In view of the high costs of such research programs, the EC should promote European cooperation in the marine resource areas to optimize using available facilities as well as developing interfaces with industrial applications. This is an area where cooperation with other countries that have large marine research programs may appear desirable as well.

G. Science and Technology for Development

The Board feels that joint programs are not sufficient to achieve the strengthening of local S&T systems of least-developed countries (LDC). Instead, funds should be channeled towards development of S&T infrastructures, particularly in Africa⁴, in agriculture, health, environment, civil engineering, urban planning, geology, marine sciences, and social sciences. The Board feels that in this context, adaptation of technologies, based on appreciation of real needs, may play a more important role in economic development than research. Resources must be allocated to update and develop the knowledge

base and to assist scientists and technologists from LDCs to access this knowledge.

H. Scientific and Technical Cooperation

The largest programs in this area are the SCIENCE program (discussed earlier) and SPES. These programs aim to link researchers in member states and to raise a consciousness about a common European scientific and technological community. The flexible funding mechanisms provide EC scientists incentives to move rapidly into promising areas of investigation where pooling of resources and facilities allow rapid scientific progress and exploitation of opportunities.

The Board recommends that the EC should also exploit existing organizations for European cooperation in science such as the ESF to organize, fund, and supervise research networks, postdoctoral exchange programs, and high-level training workshops for researchers in the community. Experiences with ESF in this area have been very encouraging so far.

To take advantage of the bottoms-up approach, the EC should fund, on an equal basis, small exploratory programs jointly proposed by university teams of different countries that could take place through existing institutional channels. Administration would be minimized since member participation would be built in from the start.

In programs that encourage mobility of scientists, the Board foresees a danger arising from a drain of human resources from peripheral countries to more advanced areas of the community, therefore limiting the capacity of peripheral countries to generate new talent. Creating new poles that would reverse this process by attracting scientists from more developed areas would be advantageous. The EC should meet this challenge to prevent scientific desertification at the periphery once EC scientific mobility becomes a reality. With this aim, the EC should establish networks of centers of excellence throughout the community, with nodes in several locations. These nodes would contribute to spread information and to train the human resources that can use it. In this respect, VALUE could play a substantial role, as well as European Community Action Scheme for Mobility of University Students (ERASMUS) and Community Action Program for Education and Training for Technology (COMETT).

The JRC at Ispra, IT has remained isolated in the European S&T context because of ageing of staff, inadequate staff turnover, and the disproportionate share of personnel and overhead costs in total expenditure. The 1988-1991 program gives the JRC an opportunity for renewal through a new orientation in environmental protection, safety, and advanced materials that fit well within the objectives of the Framework program. The JRC could host future large-scale facilities for European re-

⁴Accounts for Europe's colonial past.

search where existing skills and infrastructure could be beneficial. The JRC should also be encouraged to expand its policy to seek outside customers for its activities since customer-oriented work will bring it closer to the needs and realities of S&T in Europe. At present, staff renewal appears to be the greatest challenge facing the JRC.

1990-1994 Proposed Framework Program Activities

The choice of technical objectives of the third Framework program (1990-1994) reflects added value to the EC through cooperation to pursue the twin goals of innovation and EC action. The criteria for the choice of objectives for the third program have been to: further encourage industry to pursue transnational objectives, meet challenges imposed by competition, and implant European attitudes in training young researchers. Shared cost still remains the preferred form of funding. However, where coordination of existing research at the national level is predominant, concerted action will be used.

1992-1994 Proposed Framework Strategic Elements

Following the recommendations of the Board, Pandolfi and the European Commission proposed that the 37 areas of the current Framework program be cut to six for the 1990-1994 program allowing overlap in the 1990-1992 timeframe. This reduction would discourage micromanagement by the European Community Council of Research Ministers (see 1990-1994 Program Assessment). The six areas would be: Information and Communication Technologies, Industrial and Materials Technologies, Environment, Life Sciences and Technologies, Energy, and Human Capital and Mobility.

1. **Information and Communication Technologies.** The context of the enabling technologies program element is the symbiosis between informatics and telecommunications, ever-increasing demands from users, and a requirement for a real nerve system to link a single Europe. Within this context, the program branches out into information technologies, communications technologies, and telematics and governance (see Table 12).

2. **Industrial and Materials Technologies.** The objective is to rejuvenate European manufacturing industry through science-based advanced technologies, while integrating market requirements and environmental constraints. Major integrated projects; e.g., the clean car, will have priority (see Table 13).

3. **Environment.** The aim is to provide the community with the know-how to prepare environmental quality norms, safety and technical norms, and methodologies for environmental impact assessment (see Table 14).

4. **Life Sciences and Technologies.** The long-term objective is to develop Europe's potential for understanding and using properties and structures of living matter (see Table 15).

5. **Energy.** Research in three areas will stress environmental compatibility emphasizing clean and safe energy technologies (see Table 16).

6. **Human Capital and Mobility.** To provide the European research system with human resources in exact and natural sciences, technologies, and economic science, the EC will finance the cost of training in a center of excellence in a country different from the country of origin. This investment in human capital is expected to have pervasive effects on the whole R&D system, on cohesion, and in redressing the intracommunity imbalances. Identification of centers of excellence and selection of candidates will be left to the scientific community.

Table 12. Information and Communication Technologies

- **Information Technologies** - Will stress prototypes, and distributed systems with emphasis on compatibility of suppliers. Within this background the microelectronics objective is to contribute, in conjunction with the JESSI project, to the creation of a European manufacturing capability, thereby ensuring the survival of the European electronic industry. In peripherals, the objective is to spawn new generations of mass produced, reliable, low cost input-output devices, favoring the appearance of new arrangements. Software will emphasize tools and systems that increase productivity in software production and optimization of advanced CAD/CAM systems in strategic industrial sectors.
- **Communications Technologies** - Will stress the continued development of a broadband network as well as the development of intelligent, reliable and secure networks. Will give priority to the growing demand for mobile telephony aiming at a flexible transition between successive network generations. Within this context, areas of emphasis will be:
 1. Intelligent networks incorporating new techniques of information transfer, optical communications, and artificial intelligence
 2. Issues in mobile communications such as security, efficient use of the spectrum, integration of mobile systems within universal networks, and equipment miniaturization
 3. Development of protocols and coder-decoders for efficient and error-free numerical image transmission, including HDTV
 4. Real-scale experiments in advanced communications to characterize new model services.
- **Telematics and Governance** - Will look at single market stimulated information exchange requirements at the level of public administration functions such as interior (migration), justice, customs, taxation, social security, as well as at the individual user level in transportation, health, extension education, environmental protection, and access to/from rural areas.

Table 13. Industrial and Materials Technologies

- **Materials** - Will emphasize specific properties exploiting breakthrough in understanding of microscopic structure, materials for use in extreme or unusual conditions and whole life cycle (source, manufacture, use, wear, disposal, and recycling/recovery)
- **Design** - Will reduce design-to-product leadtimes by incorporating materials selection, systems analysis, design rules for manufacture, assembly reliability and maintainability, and process control that aims at "zero defects" products. This branch will also emphasize design relevant technologies such as fluid dynamics, power systems, and acoustics
- **Manufacturing** - Will aim at greater efficient, shorter design-to-product times, reduction of in-process inventories, higher quality through mathematical modeling, and effective implementation of CAD/CAM techniques in small- and medium-sized enterprises
- **Measuring and Testing** - Will satisfy the scientific and technological know-how requirements to establish EC-wide norms, standards, and codes of practice.

Table 14. Environmental Impact Assessment

- **Global Change Program** - Will assess the process, and the impact of human activities on environmental change, including geographical regions outside the EC such as the poles. The EC participation will take place on biogeochemical cycles, atmospheric chemistry, physical and chemical oceanography, and climate
- **Environmental Technology** - Will aim at monitoring techniques, remote sensing, and technology for environment rehabilitation
- **Integrated Projects** - Will involve major environmental issues on a regional basis
- **Research on Economic and Social Aspects** - Will study legal and ethical aspects of environmental policy such as risk assessment, public perception, management, economic evaluation of environmental impact, socioeconomic impact of implementation of environmental policies, and effectiveness and consistency of environmental laws across national borders.

Table 15. Life Sciences and Technologies

- **Basic Biotechnology** - Will strengthen the science base thorough research centered on understanding biological information, transformation and control systems, including genome analysis, neurobiology, immunology, macromolecular modeling, and nutrition Agricultural and Agro-Industrial Research. Will consider the objectives of the EC Common Agricultural Policy and rural development in genetically built-in resistance to adverse agents, production of new biodegradable products, and biomass energy sources. Will contribute to major interdisciplinary programs such as finding effective remedies for desertification and will have an aquaculture and fisheries component.
- **Biomedical Research** - Will find new approaches to curing and preventing socially and economically relevant diseases through epidemiology, experimental, and clinical research. In oncology, attention shifts to early detection of oncogenic factors and new tests for cancer chemotherapeutic agents. New AIDS-related activities will address chemotherapy and vaccines.
- **Life Sciences for Developing Countries** - Will consider integrated strategies for food production and environmental protection/restoration, and combating major tropical disease.

Table 16. Environmentally Compatible Energy Research

- **Fossil Fuels, Renewable Energy Sources and Energy Utilization** - Will consider environmental impacts such as the greenhouse effect and acid rain. Research will look at hydrogen and other alternative fuels, zero emission power; i.e., photovoltaic electricity generation with minimum environmental impact, solar and wind power. Energy production and conservation technologies will be developed based upon recent breakthroughs in understanding combustion and developments in electrolytes and catalysts.
- **Nuclear Fission Safety** - Will give new impulse to reactor safety, radioactive waste management, fuel elements, actinides, and accountability of fissile materials. Radiation protection research will include the natural background, medical exposure, a better definition of the risks of low-dose exposures and technologies to assess the radiological consequences of nuclear accidents.
- **Controlled Fusion** - Will extend the life of the JET to 1996 to achieve control of plasma conditions close to those of the Next Step (Engineering Fusion Test Reactor) (Kenward, 1990). Detailed design of the Next Step experiment will continue. Existing research devices will be phased out at the conclusion of their experimental programs. "Keep in touch" activities in inertial fusion will be developed through fundamental research on laser-plasma interactions and possibly heavy ion beam-plasma interactions.

1990-1994 Program Assessment

The six-area 1990-1994 program, as described above, is a political document that represents a least-common denominator of what Pandolfi thinks may be acceptable to the European Parliament. An unmistakable feature is the emphasis given to environmental issues. This emphasis reflects the clout of the environmental movement in European politics. However, the lack of detail on the actual research planned, the priorities within each one of the six areas and who would establish the priorities, caused difficulties at the September 1989 meeting of the European Communities Council of [Research] Ministers (Council).⁵ These Ministers represent the national interests, providing a counterweight to the Commission, whose outlook is EC-wide rather than national (Owen, 1989), and causing some fear that the Ministers might lose control on how research money was divided (MacKenzie, 1989).

Consequently, in September 1989, the Council tasked Pandolfi to be more precise; thus, in November, Pandolfi provided a breakdown to the Council of how the monies would be spent. A tentative agreement was reached in the November 1989 Council meeting on how the monies should be divided among the major activities. As an example, the 15 to 20 percent of the 1.1 billion ECU spent on energy activities would be devoted to renewable resources, fission safety-23 to 27 percent, and fusion-55 to 60 percent.

On December 15, 1989, the Council reached a political agreement on the overall Framework program for 5.7 billion ECU (approximately \$6.7 billion). The Commission had originally proposed a Framework funding proposal of 7.7 ECU; however, Pandolfi reminded everyone at the end of the Council meeting that the remaining 3.1 billion ECU under the previous second Framework covering 1990 and 1991 would be added to the 5.7 billion just approved for the third Framework. This means the Council has reached an agreement on a Framework funding of 8.8 billion ECU available for various research programs over the next 5 years.

Development of the Research Budget

The Commission had originally proposed funding 7.7 billion ECU for the third research Framework program. The European Parliament proposed 8.2 billion ECU and asked for better integration of EC small businesses into the program, claiming that the third program should focus more on basic and precompetitive research and be open more to third countries, such as European Free

Trade Association (EFTA), Eastern European, and third world countries.

During the Council meeting on December 15, Spain, the Netherlands, and the U.K. were arguing for even lower Framework funding than the 5.7 billion ECU finally approved by the Council. Only France and Italy were pushing for approval of the Commission's total proposal of 7.7 billion ECU, funding that Spain and the U.K. considered excessive. Agreement was reached because of pressure from the French Council Presidency (Hubert Curien, Research Minister) to reach a conclusion on research funding before the end of its term in December 1989 (see ESNIB 89-04:67 and 89-10:44).

The Council now enters a consultation period with the European Parliament with regard to the different Framework funding levels preferred by the Council and the Parliament. By February 1990, under the Irish Council Presidency, the Council will then formally (legally) adopt the Framework program that it reached a political agreement on December 1989. During this consultation period, the Council must consult the Parliament, but does not necessarily have to accept its amendments. After the Council has formally adopted its previous decision, the Council and the Parliament will then enter the cooperation procedure during 1990 for the specific funding of each of the 15 categories under the Framework program. Unlike the consultation procedure, the cooperation procedure will allow the Parliament to amend the Council's specific funding priorities. The Parliament has more powers to influence the specific funding priorities than it does with the overall Framework level. However, the overall Framework program is subject to review and renewal every 3 years, with the last 2 years of each 5-year program folding into the next Framework program. Therefore, the fourth Framework program will be established at the end of 1992.

During the marathon 15-hour Council session, in addition to disagreement on the overall funding level, there was considerable disagreement on the actual allocation of the funds. Because of this impasse, the Council adopted the Commission's original breakdown.

The new Framework program will be simpler and more flexible than the previous one, with 15 categories of research replacing the previous 37 and the proposed 6. This allows for less micromanagement of the Commission's funding decisions by the Council. The Commission had really wanted as few as six broad funding categories, but the Council was concerned that this would give the Commission too much power.

Table 4 provides the breakdown of the 5.7 billion-ECU funding. The program includes enhanced expenditure on environmental research, a new program for the pan-European information network and funds for training of postgraduates outside their native countries.

⁵The European Communities Council of [] Ministers is an ad hoc body representing the EC governments; it is composed of national ministers responsible for the [] area, in this case [Research].

The Research Council also approved a study of the terms of closer cooperation with the countries of Eastern, and now Central Europe in the area of research, especially in areas having a direct impact on the population, such as the environment and health. This initiative, which includes the promotion of exchanges and the free movement of scientists, has acquired a new meaning after the events of Fall, 1989.

Questions remain on funding levels that must be agreed to by the Commission (Directorates General), the Council, and, ultimately, the European Parliament. These discussions reflect a continuing tension between individual governments and the Commission on who is ultimately responsible for the direction of research in Europe.

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Framework Program News from Brussels

by Patricia Haigh, U.S. Mission to the European Committee (USEC), Brussels

On February 26, the EC Council of [Research] Ministers held a consultation with a delegation from the European Parliament on funding for the revised 1990-1994 Framework Program. At their December 1989 meeting, the Council agreed on a political compromise providing for a total funding of 5.7 billion ECU which was 2 billion ECU less than the European Commission proposal. Since then, the European Parliament has objected to the proposed funding level of 2.5 billion ECU for 1990-1992; this was 200,000 ECU lower than the amount available under the multi-year pact on EC finances concluded by Council and Parliament, the two branches that comprise the budgetary authority. Parliament also questioned the Framework Program priorities.

The Council President tabled a series of declarations from the Council aimed at answering Parliament's concerns. Although the Parliament delegation was not satisfied with the Council's refusal to spend extra money, it did not want to delay implementing the specific research programs to be financed under the Framework Program. The Council's declaration were therefore referred to Parliament committees for further study. The Council and Parliament will keep in touch with a view to narrowing their differences.

In medical and sanitary research, the Council approved the conclusion of bilateral cooperation agreements with five EFTA countries—Austria, Switzerland, Sweden, Finland, and Norway. Financial contributions of the contracting parties will be determined by a GDP-based ratio.

The Council also held an informal debate on R&D cooperation with Eastern European countries. While waiting for a communication that the Commission is preparing on the subject, they reaffirmed the EC's readiness to cooperate with Eastern and Central European countries in support of political and economic reforms. However, no concrete decision emerged from the debate. Any expenditures resulting from S&T cooperation with Eastern Europe would have to be financed from funds other than those earmarked for the Framework Program.

Regarding the International Thermonuclear Experimental Reactor Program of International Cooperation in Thermonuclear Fusion, the Council is waiting for a draft negotiating mandate from the Commission to negotiate with the U.S., U.S.S.R., and Japan.

Summary of First Report on the State of Science and Technology in Europe

by G. Patrick Johnson, European representative for the National Science Foundation. Dr. Johnson is attached to the American Embassy in Paris, France.

Background

In June 1987, the Committee on Energy, Research, and Technology of the European Parliament (Parliament) published a report entitled "Comparative Study of the Technology Level of Europe, USA, Japan and the Soviet Union." In that report, the Parliament invited the Commission of the European Communities (CEC) to prepare a report on the European situation in various fields of S&T as a basis for considering future policy requirements. In late 1988, the Commission responded to the request by publishing the "First Report on the State of Science and Technology in Europe." This paper summarizes the information contained in that report. The report is currently being updated and is expected to serve as a framework for future reports.

The report attempts to develop a balance sheet of progress to date of the improvements in the position of Europe in S&T. The report also examines the main research needs and opportunities that could reduce Europe's technological dependence and improve its competitiveness and the quality of life. Finally, the report identifies the key science policy issues facing Europe over the coming years. The report takes a broad view and is not limited to EC activities. The report attempts to develop a factual basis for considering what needs to be done in Europe without specifying whether actions should be taken at national or transnational levels. The report stresses the importance for Europe's future of adequate support of "the application of scientific knowledge and technical know-how to the solution of the main economic and societal questions facing Europe." The report addresses questions of education and technology transfer and pays particular attention to the opportunities and needs arising from the completion of the EC's Internal Market in 1992. The report contains five chapters which I summarized in the following text.

Chapter I. Science, Technology, and Europe's Economic and Social Needs

Science, Technology, and the Economy. In March 1988, the CEC published a report analyzing the economic benefits of completing the EC's Internal Market. That report pointed out that world demand for products in high-technology sectors such as electronics, chemicals,

and pharmaceuticals has been growing at twice the rate of manufactured products as a whole. The report then noted that in 1985 those sectors accounted for only 22.4 percent of the value-added from industry throughout the EC. At the same time, those sectors accounted for 29 percent of value-added in the U.S. and 28 percent in Japan. Also, Europe's share has been growing by only about 3 percent per year while that of the U.S. grew by 3.7 percent and Japan's grew by over 17 percent. Between 1979 and 1985, Japan increased its world market share for electrical and electronic equipment by about 12 percent. As a result of these trends, Europe has been losing ground in terms of exports in the world market. At the same time, the EC has been increasing its dependence on imports of high-technology products. The report points out that the increase of trade dependence also reflects an important underlying technological dependence in some sectors.

Although Europe is under-represented in high-growth industries, European industry remains significant in traditional manufacturing. When comparing the combined GDP of the EC, the U.S., and Japan, the EC accounts for some 35 percent of total, but it produced 44 percent of the cars, 42 percent of the steel, and 40 percent of the textiles and clothing. The report summarizes this situation by stating that Europe's interest lies in reducing its dependence in the high-growth sectors where new industries are emerging and harnessing new technologies to improve the competitiveness of its traditional industries.

In characterizing emerging industries, the report identifies five features:

1. Heavily science-based
2. Emergence of new generic technologies
3. Increasing range of scientific disciplines
4. Close and interactive relationship between fundamental research and commercial production
5. Pace of economic growth that will stem from emerging industries linked to diffusion, application, and modification of new generic technologies by smaller, innovative firms.

The importance of S&T for economic progress is certain to grow in the future particularly in sectors such as information technology (IT) and biotechnology. Advances in materials science could bring about significant

savings and affect existing international comparative advantage. The report describes a world economy that is in a state of rapid change where growth and competitiveness will increasingly depend on a successful interaction between progress in scientific knowledge (science push) and the identification of market opportunities and needs (market pull). In its analysis, the CEC has determined that the removal of market barriers within Europe will be important in helping to improve competitiveness. But that will not be enough. Adequate public policies on R&D will be required that support the new realities of ever-closer links between science, technology, and the market place. Those policies must create the conditions in which those links and interactions can be established in Europe.

Science, Technology, and the Consequences of Growth and Change. The report points out that the improvement of European competitiveness is not the only issue about which science policy should be concerned. There are social issues that stem from technological change that also must be addressed. Among these are the effects of technology changes in employment patterns, the distribution of wealth and economic opportunity, and the implications of those changes for social and economic cohesion in Europe. There are also environmental and ethical issues. And finally, the report notes that new questions are emerging for international relations, and European science policy has an important role to play in this area also.

The Changing Scientific Environment. Changing factors of the scientific enterprise itself will also be important for science policy. These include the accelerating pace of scientific discoveries, the increasing cost of research, and the trend toward a multidisciplinary approach to research. These factors combine to require that financial resources be depreciated faster and at the same time be directed at an ever-growing number of problems. For science policy at both the national and European level, this means that resources--financial, human, and physical--must be applied in a highly rational manner. Research priorities will be difficult to define and duplication must be avoided and efforts must be pooled.

Chapter II. European Science and Technology from a Comparative Perspective

In this chapter, the report analyzes trends in resource inputs to S&T in the U.S., Japan, and Europe and associated outputs. Data for 1985 for the U.S., Japan, and Europe are used because this is the latest year for which comparable data are available.

Inputs. In absolute terms, total spending on R&D (civil and military) in the U.S. was 1.75 times that of the EC and 2.9 times that of Japan. In terms of R&D intensity (R&D expenditures as a percent of GDP), the U.S. ex-

pended 2.8 percent, Japan 2.6 percent, and the 12 EC countries expended 1.9 percent. Only the FRG had an R&D intensity comparable to the U.S. and Japan, and the levels among the other EC countries vary greatly. When defense R&D is excluded, the U.S. intensity drops to 1.9 percent, the EC drops to 1.4 percent, and Japan's is essentially unchanged. Between 1981 and 1985, Japan's rate of growth in R&D spending as a percent of GDP was twice that of the U.S. and Europe.

Expenditures and Execution--The Contribution of Public and Private Sectors. About one-half of U.S. spending on R&D is financed from public sources while more than 70 percent is performed by industry. In Japan, industry finances and performs about 70 percent. In the EC, only the FRG and Belgium have shares of R&D performed by industry that are on a par with the U.S. and Japan. In most EC countries, there is a significantly lower level of industrial performance of R&D.

R&D Personnel. In 1986, the U.S. had a much larger R&D workforce (825,000) than either the EC (estimated to be 500,000) or Japan (400,000). The U.S. figure has been relatively stagnant while Japan's has increased steadily and sharply.

Output from R&D. The three proxy measures for output of applied R&D used in the report are patents, technological balance-of-payments, and balance-of-trade in high-technology goods. Japan ranks above the U.S. and Europe in total patent applications and those granted domestically. In terms of those registered with foreign patent offices, Japan ranks third after the U.S. and the FRG. In terms of technological balance-of-payments, Japan has moved from a negative position to about zero. In export/import ratios, the Japanese ratio has been growing in all key sectors while the U.S. position has weakened. The proxy measures for outputs from basic research are number and disciplines of Nobel prizes, and numbers of scientific papers published. Between 1946 and 1987, U.S. scientists won 196 Nobel prizes, Europe (EC plus EFTA countries) won 105, and Japan won 5. The report shows a comparison of the distribution of published scientific work for 1973 and 1982. In 1973, the U.S. had 54.4 percent, Europe had 38.5 percent, and Japan had 7.1 percent. By 1982, Japan had increased to 10.1 percent; the U.S. decreased to 51.1 percent; Europe increased slightly at 38.8 percent.

Trends in the U.S. The report has a section on the U.S. R&D situation. The report states that between Fiscal Years (FY) 1980 and 1988, Federal spending in the U.S. on R&D grew by an estimated 26 percent in real terms while that for civilian R&D fell by 24 percent. In FY 1988, defense accounted for 67 percent of Federal R&D compared to 46 percent in FY 1980. Development, the fastest growing component, doubled during the period while defense funding of basic research fell in real terms. The picture is almost the opposite for nondefense research.

While spending on civilian research decreased during that period, spending on basic research actually increased by 40 percent. The trends highlighted by the report show a flattening of expenditures on energy research, increasing expenditures in health research, and increasing expenditures in general science.

In discussing spinoffs from military R&D, the report states that these have been important in fields of materials, aircraft engineering, vehicle technology, computer technology, and systems engineering. As defense R&D has become more closely directed toward weapons systems and communication equipment, doubts have been raised in the U.S. about its broader industrial benefits. The report notes that U.S. administrations have responded with measures to enhance those benefits; e.g., the Federal Technology Transfer Act and the "Competitiveness Initiative." The report discusses the steps taken by U.S. administrations to promote industrial cooperation. The first efforts toward promotion of industrial cooperation were taken under the Carter administration through some relaxation of antitrust regulations. The report mentions the National Cooperative Research Act and one of its offspring, SEMATECH, along with the Small Business Innovation Program, as examples of initiatives designed to help the U.S. recapture markets. The report states that it is too early to judge the success of the various initiatives to promote cooperation in the U.S.

From an international perspective, the potential reduction of scientific openness and selective admittance of foreign participants in some programs is an issue of major controversy stemming from U.S. concerns about leakage. Those concerns have led to a new approach by the U.S. for international collaboration in S&T. Because of the enormous costs of mega projects such as superconducting super collider (SSC) and human genome, pressures have militated in favor of more international collaboration. However, concerns about leakage have led the U.S. to approach international cooperation on the principle of symmetrical access. The report notes that this approach is reflected in the recent R&D cooperative agreement with Japan.

The report discusses U.S. concerns about the longer-term output of scientists and engineers. There has been no growth in the share of R&D personnel in the labor force in the U.S. for several years. The report references one study that estimates a shortfall of more than 500,000 scientists and engineers by 2010. The report also states that meeting this shortfall will require recruiting more women and minorities to become scientists and engineers, on the one hand; on the other hand, encouraging more foreign students to study and stay in the U.S. Finally, the report notes that at the postdoctoral level there will be increasing pressure for the U.S. to poach skilled R&D personnel from abroad.

Developments in Japan. The report points to the impressive record of Japan between 1955 and 1985 where its share of the total R&D expenditures of the six largest industrial countries rose from 1 to 16 percent. During that time, Japan moved to second place among countries of the free world in numbers of researchers. The bulk of that Japanese effort has been in the civil R&D field and the private sector has accounted for the largest share of the increase in R&D expenditure. For 1986 in natural sciences, the public sector accounted for only about 17.6 percent of total R&D while the private sector provided 82.4 percent. But the report notes that the private sector efforts have taken place within the framework of a tradition of long-term and consensus planning and linkages between industry, government ministries, and agencies. This has played a crucial coordinating role among industry, universities, and government agencies. *Strategies covering ten- to twenty-year periods are common in government and industry.* Complex networks of outlooks on developments in R&D have emerged through these arrangements. Tax incentives, subsidies, and conditioned loans have also encouraged industry to allocate resources to R&D.

Although some changes are beginning to come about, the bulk of Japanese R&D has traditionally been devoted to applied research. From the mid-sixties, efforts such as the Large-Scale Project Program brought together researchers from industry and universities to give Japan a leading edge in strategically important applied technologies. The focus in Japan leaned heavily toward applied research; e.g., in 1987, only 13.3 percent of total R&D was allocated to basic research. Now the emphasis may be beginning to change. According to the report, qualitative evidence of a new preoccupation in industry and government with Japan's basic research capacity is a key factor conditioning economic and social progress in the longer term. These concerns were outlined in the 1987 and 1988 White Papers on Science and Technology by the Japanese Science and Technology Administration. Although those papers demonstrated progress in basic research by documenting Japanese contributions to major scientific journals, they also point out the weakness of Japan's basic research vis-a-vis industrial technology. The 1988 paper argues that research in basic sciences is insufficient compared to research on application and development, partly because of a low level of basic research funding by government. The paper also points out that more researchers are needed with masters and doctoral degrees, that there are fewer science graduates than engineers, and that there is a lack of large-scale research facilities and data bases. This recognition of the importance, for the longer term, of basic research has led to a new emphasis in Japan for international cooperation. Programs have been started to facilitate the participation of foreign scientists in Japanese programs, and the Human Frontier

Science Program was initiated to help remedy shortcomings and respond to criticism of the closed nature of the S&T systems in Japan. An important future issue is to ensure that the cooperation that ensues from these activities provides benefits to all parties.

A Changing International Environment. This section of the report discusses factors, besides the changes in the U.S. and Japan, that could impact the international environment in which European S&T develops in the longer term. The report states that the future direction of the Soviet economy and the longer-term results of S&T policies in newly industrializing countries (NICs) and China are particularly important for Europe.

Military R&D in the U.S.S.R. takes up most of the scientific resources today, but Gorbachev's programs to reform and modernize the economy, if successful, will inevitably mean a reallocation of some S&T to civil uses. Over time, the U.S.S.R. could become an important force in S&T. The U.S.S.R. has considerable S&T capabilities in mathematics, computer science, space, advanced materials, and molecular biology. By some estimates, the U.S.S.R. has 65 percent more scientists and engineers engaged in R&D than the U.S. (in terms of proportion of the labor force). This is the largest number of any country in the world. Reforms that improve the effectiveness of these significant S&T resources would portend substantial changes in the global S&T environment.

Recently, Europe has faced increased competitive pressure from NICs in Asia and Latin America, both in traditional industries and high-technology sectors. The report cautions that the challenge will become even more serious as the more established NICs face new competition from other industrializing countries with labor cost advantages and from offensive technology development strategies of the developed countries. The most dynamic NICs are planning substantial growth in R&D spending and are developing an S&T labor force comparable in quality to the U.S., but with a much lower labor costs. Korea is a prime example, where R&D spending is expected to reach 3 percent of gross national product (GNP) by 1991, and R&D personnel are expected to grow to 30 per 10,000 of the labor force.

Other industrializing countries in Asia and Latin America have recognized the importance of building an S&T capacity--notably Taiwan, Brazil, India, Israel, Hong Kong, Singapore, and Argentina--and these countries will add to the challenge for Europe.

The report also discusses developments in China where improvement in S&T capacity is seen as fundamental to the achievement of long-term goals of economic growth and development. According to the report, China has major R&D programs in seven areas--biotechnology, aerospace, IT, lasers, robotics, energy, and advanced materials. Other programs are aimed at increasing the level of S&T education and technological inputs to export

industries. The report ends the discussion of the changing international S&T environment with a warning: while it is impossible to predict the long-term consequences of these global trends in S&T, the increased importance being given worldwide to S&T and the emergence of significant new S&T powers cannot be ignored by European countries in setting their own S&T policies.

Chapter III. Mobilizing Europe's Resources

In this chapter, the report examines the responses to Europe's challenges in S&T from the national level and in terms of European cooperative activities.

At the National Level. During the 1980s, there has been considerable rethinking in Europe of national S&T policies. Redefinitions of public sector priorities have occurred both between S&T and other policy arenas, as well as rearrangements of S&T budgets. Throughout Europe, R&D is being given an important industrial orientation; moves are being made to improve university/industry cooperation; concern is being focused on patterns of higher education at the input side, and on the pace of innovation at the output end; and value for money is being sought in choosing funding priorities. The U.K. is conducting a major science policy review; Italy and Spain have made important changes in administration of science policy; and the FRG has recently shifted the pattern of Federal R&D spending. But the situation differs considerably among the EC countries in the share of GDP devoted to R&D, in the relative importance of public and private sectors, and in the areas to which R&D is focused. The FRG, the U.K., and France together account for over three-fourths of total public and private expenditures for R&D in the EC. These three countries, together with the Netherlands, have higher than the EC average shares of GDP allocated to R&D in the EC. Spain, Portugal, and Greece are at the other end of the spectrum, with far less than 1 percent of GDP for R&D. Public policy in each of those three countries has emphasized the need to increase R&D spending, but only Spain has achieved significant results. The remaining EC countries lie between these two extremes. Italy's performance has been striking. Real growth in Italy's resources devoted to R&D grew by 10 percent per year throughout the 1980s, reaching 1.5 percent of GNP by 1986. The report emphasizes that wide differences exist among countries not only in financial resources for R&D but also in terms of manpower. The FRG and France together account for over one-half of all EC R&D personnel.

The relative importance of the public and private sectors as sources of funding and performers of R&D also varies widely. In all EC countries, the public sector is an important source of R&D funding, and only in the FRG and Belgium is public expenditure on R&D less than that of industry. The FRG's increase in total expenditures for

R&D has come mainly from increased industrial spending, while in France and Italy gains in R&D intensity are principally from increased government expenditures. The EC countries vary widely not only in R&D intensities (both total- and industry-intensity), but also in levels of employment in technology-based industries. These differences are accentuated even more at the regional level.

Trends in National R&D Policies and Public Funding.

Most of the EC countries experienced real growth in government expenditures for R&D during the 1980s. The exceptions are the U.K., where funding remained level, and the FRG where only modest increases in government spending occurred, but where industry support for R&D provided the major share of growth in total R&D expenditures. Wide differences occur among the EC countries as to the distribution of public funds among R&D categories. In the U.K., 51 percent of government R&D is for defense. In France, defense R&D is 34 percent of government R&D and in the FRG it has a 12.5 percent share. In the civilian R&D category, the Netherlands, Belgium, the FRG, and Denmark have above-average shares of total publicly funded R&D going to universities and nonoriented research. In the U.K., the percentage of public R&D funds to these categories is below average. In France, university funding is below average.

Environmental research receives higher-than-average shares of public funds in the FRG and the Netherlands; Italy has focused on energy research; Greece, Denmark, Ireland, and Portugal focus on R&D to improve agricultural productivity. But in general, the most important growth sector across the board has been in R&D on industrial technologies. This general feature of European R&D reflects the growing industrial orientation of the R&D policies of the individual EC countries. These policies are characterized by:

- Increased spending by industry on R&D
- Support on high technologies with major industrial applications
- Better technology transfer
- New emphasis on cooperation between government research organizations, higher education institutions, and industry.

The report points out that the increased orientation of R&D to industrial uses has led to an emphasis on public support for downstream R&D with more immediate commercial application. Although this varies considerably across the countries, the balance of public R&D has shifted in many EC countries away from basic research and toward applied research. Tight budgets, the rising costs of basic research, and increasing emphasis on cost effectiveness have all contributed to this so-called "shift from science to technology policy" in Europe. France, the FRG, and the Netherlands continue to give high priority

to basic research along with that of precompetitive, industry-oriented R&D. On the other hand, the U.K. has downgraded the public support of basic research in favor of precompetitive R&D. The report provides one-page outlines of each EC country giving comparative statistics with outlines of each country's science policy and priorities (see European Science Item 89-02). The report identifies key areas where common features in technological requirements for both defense and civil technologies occur. These so-called dual areas include: sensors and signal/image processing, complex system design and information processing, man/machine interfaces, vehicle technology, advanced design and manufacturing technology, electronics, microelectronics, optoelectronics, bioelectronics, communications, advanced materials, medical technology, electrical and mechanical engineering, and energy conversion.

Although individual countries have implemented programs to avoid unnecessary duplication between their civil and defense R&D in many of these areas, the report states that more should be done in other national program areas. But the most significant duplication occurs among European countries, particularly in areas driven by defense applications. As in the U.S., the increasing cost of some dual-use technologies has led defense departments to reduce their support and concentrate their resources on military-specific technologies. The report concludes that while this reduces the risk of duplication, it also implies the need for additional effort by industry or government programs to maintain a broad competitive technology frame in Europe.

European S&T Cooperation. The report reviews the history of collaborative research ventures in Europe--European Organization for Nuclear Research (CERN) established in 1953; European Space Agency (ESA) established in 1962; and Airbus Industries established in 1970. The first EC collaboration began in 1955 in coal and steel research and was followed by cooperation on nuclear research under the Euratom Treaty of 1958. In 1971, the Cooperation on Science and Technology (COST) framework began to involve the EC with other European countries. In the 1980s, the EC collaboration has undergone both qualitative and quantitative changes characterized by industry-oriented "second generation" R&D programs, medium-term planning, and EC actions both upstream; e.g., education and training, and downstream; e.g., support for innovation. And now the EC cooperation in S&T is a political commitment specified in the Single European Act (Act). That commitment involves:

- Strengthening the S&T basis of European industry and encouraging its international competitiveness
- Encouraging and supporting cooperative efforts among industry, research centers, and universities

- Adopting a **Framework** Program as a medium-term planning tool (see article on page 7).

The key elements of the EC program emphasize information technologies, telecommunications, modernization of industry, biotechnology, marine S&T, nuclear research (fusion and fission), and the environment as priority areas.

The ESPRIT program, the largest, began in 1984. The program is designed as a 10-year program to provide the European information industry with the basic technologies to meet competition of the 1990s. In phase I, ESPRIT had a total budget of 1.5 billion ECU. Phase I concentrated on precompetitive research in microelectronics, information processing, and application technologies; e.g., computer-aided design/computer-aided manufacturer systems. The ESPRIT II, has a 5-year budget of 3.2 billion ECU and, in addition to application-oriented research, gives some emphasis to more basic research targeted on such topics as artificial intelligence. The ESPRIT funding is shared equally between the EC and its research partners.

The second largest EC program activity is aimed at modernizing European industry through applications of new technology and developing new materials. BRITE is the largest element of this program area; it was launched in 1985 as a 4-year program jointly funded by the EC (185 million ECU), universities, and industry. The CEC recently submitted proposals for a new BRITE program that would combine the former program with the EURAM program. The new BRITE program is for 1989-1992 and is designed to attract small and medium-sized enterprises (SMEs) into participation. EC funding is planned to be 440 million ECU and up to seven percent of that will be available for fundamental research in areas where industry is hindered by weaknesses in basic sciences.

The RACE program is also industrially oriented; its purpose is to ensure that different telecommunications systems being developed in Europe remain compatible. Specifically, RACE aims to enable the EC to move toward integrated broadband communications systems based on integrated digital networks. Telephones, video-phones, cable T.V, data transmission, and electronic mail would utilize the system.

The BAP covers several research fields relevant to industrial and agricultural needs (see Table 17).

The report states that responses to both the first (1984-1987) and current (1987-1991) **Framework** Programs and demonstrates a real European desire for cross-border cooperation. The ESPRIT and BRITE programs have been massively oversubscribed. The ERASMUS program was oversubscribed by a factor of 3; in 1987, the COMETT program received proposals for 120 million ECU with an available budget of about 16 million ECU.

The report then discusses the EUREKA program, which is not a CEC-managed program; it was started in 1985 and is intended to focus on downstream R&D of an industrial application nature. The EUREKA program is therefore considered to be complementary to the precompetitive and targeted basic research of the EC programs. Total EUREKA project support now amounts to about 3.8 billion ECU or about 1 billion ECU per year. There are 213 cross-border projects and some 800 participating organizations (two-thirds industrial) involved in the program. Fields covered include IT, robotics, biotechnology, communications equipment, and other high-technology projects such as the high definition television project and the flexible automated assembly project (FAMOS). The EUREKA program also supports transportation and environmental research. The EUREKA cooperation involves industries and institutions in EC countries as well as other countries, particularly the EFTA countries. About half the projects involve organizations from the EC and EFTA.

Table 17. Biotechnology Action Programs

- **SCIENCE** (Stimulation des Coopérations Internationales et des Echanges Nécessaires aux Chercheurs en Europe) - Promotes cooperation and exchanges of research scientists among the member states (formerly STIMULATION, see page 37)
- **ERASMUS** (European Community Action Scheme for Mobility of University Students) - Encourages student mobility and cooperation among European higher education institutes
- **COMETT** (Community Action for Education and Training for Technology) - Promotes strong and long-lasting partnerships for training between industry and universities, notably in areas of high technology
- **VALUE** (Valorization and Utilization for Europe) - Promotes the effective dissemination of the results from research activities and contributes to their application
- **EUROTRA** (European Translation Program) - Works towards eliminating language barriers to information circulation
- **SPRINT** (Strategic Program for Innovation and Technology) - Encourages innovation that aims to create more favourable conditions for innovation and technology transfer in general, as well as other sectoral programs; e.g., STAR (telecommunications) and VALOREN (energy technologies), specifically oriented towards the needs of the less-developed European regions
- **IMPACT** - Promotes the application of new information and communication technologies to develop the information services market through specific programs; e.g., AIM, DRIVE, and DELTA in the transportation sector.

Policy Coordination. According to the report, total public and private spending in the EC on civil R&D is about 50 billion ECU per year. At present, EC total science programs amount to about 1 billion ECU per year. So, assuming 50 percent cost sharing, only 4 percent of the collective sum of the 12 EC countries' R&D expenditures is on EC programs. Even when all other European programs such as CERN, ESA, European Molecular Biotechnology Laboratory (EMBL), EUREKA are included, the bulk of R&D funding comes from national level programs. This suggests a need for better coordination of national policies to avoid fragmentation and duplication. But several factors constrain coordination. They include the differences among EC countries in R&D capacity, in the balance between civilian and military R&D, in different levels of involvement of public and private sectors, in different traditions in higher education, and in different national priorities that reflect social and economical concerns of the individual countries.

Currently, broad policy coordination is limited to exchanges of information about policies and programs and exchanges of views among national scientific advisors. The report asserts that the pressures of the Internal Market will militate in favor of further policy coordination. Some of these pressures include the need to develop common standards, the evolution of public procurement, and the requirements of competition policy. The report states that vigorous pursuit of coordination as specified in the Act is required. Future updates of this report on the state of S&T will focus particularly on coordination issues.

Chapter IV. Research Issues for the Future

In this chapter, the report reiterates the three main challenges that face the EC:

1. Improve international competitiveness
2. Respond to the needs of society by improving the quality of life
3. Increase the capacity of Europe to pursue its own S&T options by reducing dependence on others.

The goals are interlinked because improved competitiveness generates the wealth that makes it easier to address issues of social concern. And technological independence is linked to longer-term competitiveness. Fundamental research is seen to provide Europe with the opportunities to increase the scope for self-determination about technological options rather than simply react to international economic change.

Improving Competitiveness. The report cites a 1987 study by the U.S. Department of Commerce and a 1988 report by MITI of Japan as sources for an international

consensus on the important technological areas for industry and services through the end of the century (see Table 18).

Table 18. Emerging Technologies

Japan	U.S.	EC
Electronics	Electronics	Information Technology
Software	Automation	New Materials
Engineering	Computing	Biotechnology
New Materials	Advanced Materials	Energy
Biotechnology	Medical Technology	
Biomaterials	Thin-Layer Technology	

The report then identifies five fields in which Europe has specific research needs:

1. **Information Technology and Telecommunications** - Europe has made substantial progress, but rapid, world-wide developments are occurring. Beginning in the 1980s, great concern was apparent throughout Europe about weaknesses in the IT sector. Before 1984, the European IT industry had been characterized by low market shares, low R&D and low capital investments, and a negative balance of international trade (over \$10 billion in 1984). Concerted European action, including the ESPRIT program, began in 1984, and has resulted in Europe's markets growing faster than average, increased market shares in European companies, and R&D investments comparable to international competitors. But weaknesses still exist. Overseas penetration is low, the balance of trade has not improved because the electronic components industry has not progressed, and European industry has increased its dependence on foreign supplies. A major weakness in Europe is the lack of trained personnel.

In the telecommunications sector, a relatively favorable situation exists in Europe, but it could be threatened by several factors, including

- Continuing weaknesses in the electronic components field
- New technological and market challenges (digitalization of networks, ISDN, and broadband networks)
- Spiralling costs of R&D in telecommunications
- Effects of rapid changes in the world-wide regulatory environment.

The report concludes that substantial efforts are still needed to obtain and reinforce Europe's position in telecommunications.

In IT, advances are needed in the field of electronic computers, specifically to increase memory chip capacity towards the objective of 64-Mbit chips. At the same time,

progress is required in software and advanced information processing. Key areas include operating systems, management systems for data bases, parallel architectures, and RISC architectures for microprocessors. The report states that peripherals will become increasingly important, with emphasis on integrated systems. Fundamental research is also needed in solving reliability, safety, and security problems. Also called for is "prenormative" research because of the importance of standards as Europe moves toward integrated systems for many new applications such as intelligent vehicles and transportation systems.

In the area of telecommunications, research needs are related to the establishment of broadband networks, equipment, and services expected in the mid 1990s. Research is needed for enhanced network management systems, very low-spacing integrated circuitry switching components, optoelectronic components, and optical communications systems. Research will also be needed for broadband services that can combine data, images, and voice, including service engineering techniques and advanced intelligent terminals. In the area of applications technologies, the problem is to combine, integrate, and optimize the broad range of technologies already available or under development with the objective of avoiding a proliferation of independent systems. A particular need for Europe is technology to facilitate information flows across linguistic barriers.

The report states that all these issues require further encouragement and coordination at the European level and points out the difference between Europe and its competitors in basic research in IT. In the U.S., and particularly in Japan, that research is done by industry but European industry is more short- and medium-term oriented. Thus, for necessary research to be performed, Europe requires coordinated action in basic research at the European level.

2. Industrial Materials Technologies - This area is vital to the success of manufacturing industry. The report states that progress in industrialized R&D is fundamental to Europe's long-term competitive success. Compared to the U.S. and Japan, Europe is hampered by the low levels of industrial R&D. Areas where research is needed include technologies to improve product and process quality and reliability; techniques for shaping, joining, assembling, and treating surface; catalysts and membranes; powder technology; composites; and superconducting materials. In addition to research in these areas, there is also the need for a research base for development of common norms and standards in industrial technologies and materials as preparation for the post-1992 market. The report notes that it is important to encourage industry to invest more in R&D for these areas, but that is not enough. Actions are also needed to improve the availability of skilled research

managers for industry and ways to involve top management of industry more directly in R&D projects so that R&D is more closely integrated into corporate strategies.

3. Aeronautics - Europe faces a particularly important competitive challenge in aeronautics. The report states that from 1980-1986, European industry captured 23 percent of the civil and 27 percent of the military world markets. The world market will expand substantially and increased competition can be expected. If Europe is to meet this challenge, a broad-based transnational R&D effort is required. Cooperative research between European aeronautical industries and ministries, national research institutes, and SMEs is needed in aerodynamics and flight mechanics, materials, acoustics, computation, airborne systems and equipment, propulsion integration, and design and manufacturing technologies. Attention must also be given to safety and environmental aspects of aviation as well as to common norms and standards.

4. Biological Sciences - This area is the focus of worldwide attention and offers the prospect of radical improvements in agricultural and industrial production and major commercial opportunities, in addition to their impact on medicine and the environment. In biological sciences, four areas are highlighted in the report as meriting particular attention in Europe--(1) basic plant biology, (2) molecular investigation of the genomes of complex organisms, (3) neurosciences, and (4) biotechnology-based agro/industrial research and technology development. In order to make significant advances in biotechnology, it is essential for Europe to reinvigorate the investigation of plant physiology. With major efforts during the last decade of the century, for example, it could be possible to identify the quality molecules of many plants, and this could be a major achievement for agricultural production as well as for ecological monitoring of land use. A major multidisciplinary effort involving molecular biology, physiology, and genetics at the transnational level could address the emerging problems of providing food for the world population.

Genome analysis requires complex and expensive research work. While Europe has many of the skills and resources to make a major contribution to international efforts on complex genome analysis, even the largest country cannot work on its own on such a costly endeavor. The EC possesses experience in this field through the BAP program which involved some 24 laboratories in sequencing one yeast chromosome. But because of cost and complexity, further genome analysis research in Europe will require transnational effort.

The report notes that neuroscience today is an alliance of many disciplines addressing complex problems about

how the brain functions. The field is developing rapidly and the EC has initiated the Basic Research in Adaptive Intelligence and Neurocomputing (BRAIN) program on adaptive intelligence and neurocomputing to encourage this research area. The report concludes that this initiative must be followed by other actions at the European level to pool resources and complementary skills.

The report notes that in industrial and agro/industrial applications, the European pharmaceutical industry grew rapidly in the 1980s, nearly doubling production. But it now faces several problems, including the high cost of developing new products, the short period of exclusiveness granted by current patent legislation (over 10 years from patent to marketing authorization), and increasing competition from U.S. and Japanese industries. According to the report, further efforts are needed in the agro/industrial field to expand the ECLAIR program and to establish a proposed program to improve food technology (FLAIR). That program should be complemented by European level research on nutrition. Research is also required on common standards for transborder trade in food products.

5. Energy - Adequate, secure, and environmentally acceptable energy supply is an essential prerequisite to the functioning of the European economy. In energy research, the main objectives are to provide Europe with an adequate supply at reasonable cost at the right place and time. Fusion research is already a collaborative European effort with Europe at the forefront of world-wide research on magnetic fusion. The JET program has made a large step toward demonstrating the scientific feasibility of fusion. The leading position of the EC in fusion research makes Europe an appealing partner for international collaboration. Research areas of interest in non-nuclear energies and energy-saving research for industry include renewables, rational energy use, fossil fuels, and energy modeling to understand energy systems and their interface with the economy and the environment. The EC has proposed a program to explore these areas--the JOULE program.

Improving the Quality of Life for Europe's Citizens. The report points out that S&T can make major contributions to the quality of life by helping to produce a better environment, improving health, and enhancing safety. In environmental research, the report mentions several general problem areas suitable for collective European research programs. The first area is understanding the basic phenomena associated with complex interactions of atmosphere, stratosphere, soil, inland waters, and the sea. In conducting such research, advances in basic mathematics and analytical techniques, advanced computational facilities, and remotely sensed data will be among the tools required. In the area of detection and determination of environmental changes, the need is driven by

requirements to assure the public that undesirable trends will be detected and to provide data for research on basic phenomena as outlined above. Environmental epidemiology and environmental toxicology are included in this area.

Another area for collective European research deals with prevention of environmental degradation. Key topics for this area are development of environmentally clean technologies, abatement of existing noxious effluents, and the treatment of toxic wastes. Studies on the prevention and mitigation of man-made and natural hazards will also belong to this research area. Intensified research is also needed in the area of global climate change which will require both European and world-wide cooperation. An important aspect of collaborative environmental research is the need for linkage among all transnational environmental R&D activities in Europe, including those in EUREKA and ESA. The latter is important to assure a proper balance between space instruments and the requirements of the scientific community.

Three main issues influence the research requirements in the health area---(1) rising health care costs, (2) "greying" of the European population, and (3) challenge to deal with diseases like cancer and AIDS. Public health research in the EC is about one-half that of the U.S. and amounts to about 2 percent of aggregate health care costs. While research in Europe is moving ahead in all areas, it is often fragmented (most national programs consist of many relatively small projects conducted by relatively small research teams often working independently at universities and hospitals). The report suggests that health is an area where the need for more coordination has already been recognized and concerted EC action has proved its worth. Future areas for further coordinated activity include cancer, AIDS, age-related health problems, environmental and lifestyle-related health problems, medical technology development, and health services research.

In safety, contributions from R&D are pervasive. But increased attention is needed in industrial technologies and materials, in consumer goods safety, and in work environment safety. Also, the potential of R&D to enhance road safety in the longer term is particularly great. Collaborative research efforts such as the EC's DRIVE program focused on transportation infrastructure and the PROMETHEUS of EUREKA dealing with in-car requirements are current examples of coordinated programs in this safety area. Other safety research areas include nuclear fusion, radiation protection, and reactor safety.

The report discusses bioethics as an area of growing importance caused by rapid developments in biology. An EC-wide approach is needed to avoid the emergence of widely divergent legislation by individual countries on biotechnical applications and products.

Fundamental Research. In an overview of this topic, the report states that the support of fundamental research in Europe is vitally important in its quest for independence and autonomy. Basic research support by the U.S. has increased over the last 5 years, and Japan has become fully aware of the need to strengthen its basic research. In the U.S., basic research is conducted on a broad front, with the opportunity for free individual choices; in Japan, targeted basic research prevails.

A perennial problem for basic research policy is the distribution of resources between *big* and *little* science. Western Europe has partially solved this problem by several multinational *big* science projects, such as CERN for high-energy physics, European Southern Observatory (ESO) for astronomy, ESA for space, EMBL for biology, Institut Laue-Langevin (ILL) for neutron sources, and European Synchrotron Radiation Source (ESS) for synchrotron radiation. In addition, some very large national facilities are open to bilateral collaboration.

In the *little* science area, several networking initiatives are also in place in Europe for task-sharing among individual scientists and small groups. Included among these are the ESF, the European Molecular Biology Organization (EMBO), and the EC's SCIENCE program (see European Science Item 88-12). A problem remains, however, on the question of access to advanced middle-sized research instruments and the development of expensive scientific instruments. Because of costs, it is not possible for every European country to make available ready access to all such instruments. The report argues that particular efforts are needed to provide a framework for cooperation in shared instrumentation. In 1989, the EC initiated a pilot program in this direction. Also, the Scientific and Technical Research Committee could possibly launch a feasibility study on joint European development of scientific instrumentation.

The report highlights some advances in several scientific fields. In modern mathematics, the theory of nonlinear phenomena is revolutionizing the theory and applications of dynamic systems. Implications are wide-ranging in many fields; e.g., ecology, economics, and meteorology. Nonlinear theory was pioneered in Europe, and European researchers are continuously making significant advances. In physics, greater attention must be given to exploitation of spinoffs. In this regard, closer links with industry and EC programs is an area for exploration. Specific fields in basic physics that need special attention include condensed matter, high-temperature superconductivity, thin films, liquid crystals, quasi-crystals, lasers, and advanced optics. In chemistry, discoveries are being pushed by advances in computing, mathematics, and instrumentation and pulled by biology and by market demand. The report mentions the changes wrought by computers and analytical instruments in the way chemicals are now isolated, identified, designed, and

synthesized. Europe enjoys a good position both in a market for chemistry-based products and in basic science. But problems exist in public acceptability because of toxic waste issues, and there is also a shortage of high-quality students.

In earth sciences, progress is being made in prediction of natural phenomena such as earthquakes. European coordination in deep drilling research is assured by the ESF. Europe is pursuing oceanography research through the EC MAST program and the EUREKA project EUROMAR. In the next decade, earth observations from space will provide a unique source for data. Close coordination among space agencies and ESA will be required to maintain a balance between space missions and the needs of the scientific community as pointed out above. And the use of space data requires timely development of interpretation methods and techniques that will require enhanced European coordination.

The report summarizes the activities in basic research in Europe by pointing out that needs for more fundamental research are met in several ways. They are met partly by national programs, by specific transnational agencies such as CERN, and by EC programs. The added value brought to basic research by EC programs is the facilitation of complementary skills and a widening of the cultural space in research. But particular efforts still must be made to avoid duplication and ensure the greatest degree of industrial spinoff from the variety of European programs.

Chapter V. Key Issues for Science and Technology Policy in Europe

The report states that there are ten broad issues of importance to Europe as it moves toward the creation of a technological Community. The discussion in the report on each of these issues is summarized below.

1. The Balance Between Basic and Applied Research. Constrained public funding and the need to focus research toward industrial needs has resulted in reduced support for more fundamental research in Europe. But the risk is emerging that this shift in emphasis may be coming at a time when Europe's competitors are moving toward increased support for basic science. For example, the S&T Ministers of the Organization for Economic Cooperation and Development (OECD) met in late 1987 and agreed that one of the key tasks of governments in science policy was to "provide the science base necessary for economic growth and for social and cultural development, and especially to support basic research." Both large and small basic research projects are requiring more sophisticated and expensive facilities and equipment, and Europe is already pooling resources in many areas of basic re-

search. This trend must be reinforced during the coming years because basic research is an essential aspect of EC efforts supporting improved competitiveness and addressing societal and environmental problems. In addition, basic research serves a vital function in training researchers. The report also urges that private industry be encouraged to invest more in longer-term basic research.

2. The Links Between Industry and the Universities.

The report cites examples of university/industry cooperation in Japan and the U.S. and notes that such arrangements vary greatly in European countries. The trend has been toward enhanced university/industry research cooperation and that trend needs further encouragement. But two key issues must be considered. The first concerns how such links could further erode the balance between basic and applied research, as discussed above. The second is the risk that exclusive arrangements between industries and universities could restrict the availability of research results. The report notes that this is already an important issue in the U.S., and the OECD recently expressed concern about the long-term implications of the trend. The EC has been able to avoid these risks in its programs by contractual arrangements that assure dissemination of results while still protecting the interests of specific research groups involved. But the issue must be considered in both national and transnational research programs.

3. Broadening and Deepening the Technology Culture.

The report emphasizes that it is primarily the skills of individuals that conduct, manage, and apply S&T. The most successful societies are those who have actively developed those skills, created a general climate of technical literacy, and encouraged the emergence of many highly trained scientists and engineers. In the past, both the U.S. and Japan have shown particular growth in scientific manpower, but the U.S. is now in a period of stagnation. In Europe, there are widespread mismatches between the output of the educational systems and the demands for skilled manpower. The smaller European countries are particularly needy in this regard, but the larger countries also have problems.

As discussed earlier, new worries about the brain drain to the U.S. are also emerging. The U.S. is not focusing exclusively on Europe in searching for S&T manpower; it is also considering whether and how to encourage Asian students to stay in the U.S. However, Europe will continue to be a major potential source of supply for research scientists. In Europe, the training and education of scientists is principally a national issue, but industry is beginning to play an important role.

As the scope of research needs grows, it is going to be increasingly difficult for even the largest European countries to offer centers of excellence in every field. There-

fore, it is increasingly important for researchers to reap the benefits of the possibilities offered by the whole of Europe. But mobility in Europe is hampered by language problems, differences in social security systems, pension arrangements, and other such practical matters. As the EC moves toward the Internal Market with removal of barriers to the free movement of labor, progress toward a researchers Europe will be greatly facilitated. More attention must be given to developing of human resources. Efforts are needed to provide an attractive environment inside Europe where the best and brightest have easy access to centers of excellence in different countries.

4. The Public Acceptability of S&T. The report points out that there are two facets to public concern for S&T in Europe: (1) concern for dangers and risks associated with new technologies, and (2) concern about ethical issues; e.g., genetic engineering. Studies have shown that considerable public confusion exists regarding the risks and benefits of technology. An improved European understanding of these issues is therefore needed. The CEC sees a role for itself in improving public understanding by designing and developing consistent and objective information. Also, it notes that the prospect of large-scale satellite broadcasting in Europe could offer new opportunities for EC-backed programs on S&T issues.

5. Encouraging the Private Sector to Invest in R&D.

According to the report, a major challenge for Europe is to increase the share of resources devoted to investment in R&D. Most European nations are well below investment levels that prevail in the U.S. and Japan. The report states that Europe must follow the example of the U.S. and Japan by having its industry become the leading source of nonmilitary R&D support. Support should not be focused solely on short-term "downstream" R&D, but must also emphasize targeted basic research for longer-term European technological advancement.

The report notes that in Europe, rates of industrial R&D investment vary widely because of national differences in tax mechanisms and venture capital markets. The EC R&D programs like BRITE and ESPRIT have played a role in inducing industrial R&D through cost-sharing procedures. However, other European mechanisms also exist to encourage small and medium business investment; e.g., The European Venture Capital Association, the Venture Consort project, and two new CEC initiatives to establish a seed capital fund as well as a European network of such funds. The CEC is also exploring ways to insure against risks of innovative R&D ventures. Loan programs by the European Investment Bank are also being created with a priority on innovative investments. The CEC is also working to improve the flows of information between potential financiers and

promoters of innovative projects by establishing a projects data base. The CEC framework for handling joint agreements between industries and government programs for R&D projects has helped balance the need for increases in R&D spending against the risk of distorting competition.

6. The Diffusion of Technology. Besides investing more in R&D, industry also must know about and understand the new technologies coming into the marketplace. Thus, technology transfer is another important aspect of the overall R&D process. Japan has a better record than Europe in this dimension. While some European countries have made major efforts in technology diffusion, the degrees of effort in other countries vary considerably. And most of these efforts are focused on spreading technologies within individual countries' borders.

The VALUE program is directed toward effective dissemination of the results of the EC's own research activities, and the SPRINT program complements that program by attempting to create more favorable conditions for innovation and technology transfer. An enlarged SPRINT program has been proposed. The importance of stimulating demand for new technologies cannot be overstressed, and organized watch programs such as Japan's need to be considered as ways to stimulate this demand. Finally, the role of the EC and its members in standardizing and normalizing technologies is also important in facilitating the adoption of technologies.

7. Increasing Coordination Among National Bodies. The report states that this will be an increasingly important issue, and a first step is to improve mutual information and understanding about national policies. Next, areas need to be identified for specific cooperation through bilateral or multilateral mechanisms. At the EC level, the report notes that the formula of concerted action has been successful in the health and environmental fields and should be more widely used.

8. Improving Cohesion of the EC. The report notes that the technological gap is even greater than the economic gap between regions of the EC. In the so-called less-favored regions (LFRs), there is lack of research infrastructure, shortage of skilled scientific manpower, and companies are less oriented toward innovation. Improvements will be essential to assure growth and development in the LFRs. Programs other than research programs, although better coordination among national R&D programs will have some spinoffs for the LFRs, and the EC's own research programs will promote development through trickling down of best practices and experience. For example, EC structural funds must be made available for infrastructure, innovation, and technical assistance for LFRs. One specific EC activity being planned in this regard is the program for Science

and Technology for Regional Innovation and Development in Europe (STRIDE). The program is a framework for the development of initiatives to improve the research, development, and technology base of LFRs in partnership with the regions themselves. But the report notes that these programs will require considerable time before they can be effective.

9. Encouraging Cooperation in S&T with Third World Countries. The report emphasizes that S&T are increasingly international commodities, and international cooperation must be a fundamental element in Europe's R&D policies. Rapid growth in transnational cooperative R&D ventures among firms, similar cooperation among universities and between universities and industries, and the growing international market in research scientists are manifestations of the increasing trend toward internationalization. (European countries have particularly intensive scientific exchanges and R&D cooperation with institutions in the U.S.)

The report asserts that further internationalization of R&D is inevitable, and that the key issue is to organize it so that it can be a positive sum game where all participants have something to gain. The report states that for the EC cooperative activities, there are three groups of countries for which different considerations apply.

(1) Other European countries, particularly the EFTA countries where cooperation has been in place under COST, has provided a framework for cooperation on specific projects with other European countries since 1971.

(2) The EC also has special bilateral cooperative agreements with six EFTA countries. Besides the EC programs, EUREKA provides a basis for cooperation with institutions in the EFTA countries and Turkey.

(3) Industrial countries outside Europe where R&D cooperation is not as well developed by the EC as with other European countries. The report states that it may now be appropriate to explore the establishment of cooperative framework with the U.S. and Japan.

The developing countries have severe special needs, much like some of the European LFRs. Europe's considerable experience in agriculture, medicine, health, and environment (partly as a consequence of colonial experiences) provides some special expertise for these countries' needs. But the efforts toward applying this expertise to LDCs' needs have often been fragmented among different national institutions. Efforts are needed to coordinate national efforts, and some of this is already underway at the EC level. Since the early 1980s, EC programs in Science and Technology for Development have been operated with Latin American, Asian, and Mediterranean countries. Those programs are aimed at the integration of research workers from these countries

into the international scientific community, improvement of their research capabilities, and technology transfer. According to the report, new programs are needed in environment, natural resource development, renewable energies, biotechnology, and materials. Outside the three groups identified above, the EC should address attention to the basis for cooperation with the U.S.S.R. and Eastern Europe as well as with the NICs.

10. Avoiding Technological Protectionism. Because of the industrialization of research and the growing importance of science in trade flows, pressure has increased to restrict S&T information caused by concerns about competition. The report states that this is a major issue for EC international cooperation in S&T, and that the CEC believes that Europe and the world economy as a whole would be losers from a more

protectionist scientific and technological world and LDCs would be even greater losers. The report emphasizes that the EC should therefore work towards ensuring the diffusion of research results and away from policies that restrict the flow of information. But while doing so, it will be necessary to assure adequate protection of intellectual and industrial property.

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The SCIENCE Plan of the Commission of the European Communities

by Marco S. Di Capua

The seeds of the SCIENCE plan were planted in 1985 under the banner of the Stimulated Action Program. The idea behind the Stimulated Action Program was to foster the concept of *European* science in contrast to *national* science within each member state in the EC. The official aim was to stimulate cooperation between laboratories in different member states and facilitate mobility of researchers within the EC. The Stimulated Action Program, which officially carried over into the SCIENCE plan in 1988, is one of many under the 1984-1987 and 1987-1991 Framework Programs. These Framework Programs set the priorities, outline the activities, and define the budgets for EC-funded research and development (R&D). Another article in this issue (The European Community Framework Program, p. 23) discusses the Framework program as a whole.

The goal of the CEC SCIENCE Plan, approved in June, 1988 (Bellemin, nd), is to prepare for 1992 by stimulating international cooperation and exchange by European scientists within the 1988-1991 timeframe. Specific objectives of the program are to establish a network of scientific and technical cooperation and interchange at the European level. The program funds bursars, research allocations, grants for workshops and high-level courses, contracts to encourage twinning of laboratories, and operations contracts in a range of activities selected on the basis of their scientific and technical quality (see Table 19).

The CEC chooses projects for funding on the basis of their quality, the extent to which the content is multi-disciplinary, their innovative aspects, and the extent to which they eliminate barriers between different forms of R&D in different parts of the EC. A reduction of disparity in scientific and technical development and a contribution to economic and social cohesion within the EC are important bases for the choice of projects through a range of activities.

Funded with 35 million ECU per year from 1988 through 1992 (167 million ECU total since 1986), the SCIENCE plan covers all fields of the exact and natural sciences such as mathematics, physics, chemistry, life sciences, earth and ocean sciences, scientific instrumentation, and engineering sciences.

Because it cuts across disciplines and national boundaries, the SCIENCE Plan, when properly channeled, could have an enormous leverage on European science. The unique aspect is that it provides a web that binds independently funded efforts in the individual countries. Therefore, it is a source of cohesion that sets directions of science research throughout Europe, greatly leveraging the EC funding.

Reference

Bellemin, L., SCIENCE, Commission of the European Communities, DG XII, 200 rue de la Loi, B-1049 Brussels, Belgium.

**Table 19. SCIENCE Plan Objectives
(since 1988)**

- To promote training and make better use through research and cooperation, respectively, of high-level researchers in the EC
- To improve the mobility of research scientists within the EC
- To develop and support intra-European scientific and technical cooperation on high-quality projects
- To promote intra-European cooperation and interchange networks with a view of reinforcing the overall scientific and technical competitiveness of the EC, thereby strengthening its economic and social cohesion.

ACOUSTICS

The Impact of the European Community and 1992 on the Science of Acoustics

by David Feit. Dr. Feit is the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until 1990 from the David Taylor Research Center, Bethesda, Maryland, where he is a research scientist in the Ship Acoustics Department.

In 1992, we anticipate that the EC will finally become a reality. What this means is that the EC will be established allowing for the free flow of trade, commerce, and people across the national boundaries of the EC members. With this undoubtedly will also come a much freer interchange of ideas and knowledge than currently exists.

In an informal sense, it is quite clear that such changes are already taking place. Recently, Professor D.G. Crighton, Cambridge University, U.K., told me that the Science and Engineering Research Council has been actively encouraging researchers to pursue collaborative type projects with their counterparts in other European universities. At the present time, the Division of Applied Math and Theoretical Physics (DAMTP) is planning a joint project with the Institute of Fluid Mechanics at the Technical University of Berlin. Several researchers were initially intimidated by the large amount of bureaucratic paperwork involved in submitting proposals to the EC Council of Research. However, after once tackling the chore successfully, they concluded that the process is not so formidable and can be fairly easily repeated with minor changes for subsequent grants.

Compared to previous years, a fairly large number of EC students subsidized by their own governments are now being educated in DAMTP at both the graduate and postgraduate levels (read as undergraduate and graduate in U.S. terms). Currently, there are eight Greek and six German students at the postgraduate level making up about 20 percent of the division's postgraduate student body. Compared to the past at Cambridge, this is a very high percentage. Because of the individual college fees that must be covered as well as university fees for Cambridge students, many European governments did not encourage their students to study here, until a new agreement at the government level on this matter was recently reached.

The EC program for the exchange of students at the graduate level is called ERASMUS, and SCIENCE is the program fostering collaborative research at the postgraduate level. There are also a fairly large number of interlocking courses where scientists from a number of the EC countries present a short course. Crighton just recently returned from the continent where he had organized a short course on Non-Linear Waves in Fluid Mechanics, which was attended by about 35 European scientists, many of whom were professors at European universities. I remember in the not-too-distant past where such a course would have been more likely presented in the U.S. to such an audience. I have heard that it is relatively easy now to obtain support for travel within the European subcontinent.

For several years, the EUROMECH group has been sponsoring specialist meetings on various focused topics in mechanics. In the past, these meetings have attracted small groups of principally European researchers and support for these meetings has been raised on an individual basis. The German representative on the EURO-MECH committee has recently proposed that these meetings be supported by the EC and should be expanded to many other scientific disciplines. There are indications that the EC views this development favorably.

The Federation of Acoustical Societies of Europe (FASE) is now very active, sponsoring a major meeting every year with two- to three-hundred participants. I recently attended an International Congress on Acoustics with some 500 participants, the great majority of them being European.

In Spring 1990, France will hold the first meeting of the French Acoustical Society; French and English are the official languages. Traditionally, the French have appeared to be rather reluctant to relinquish French as the official language in meetings held in France. In the very recent past, they appear to be making concerted efforts

to reach out to the remainder of the acoustics community. In the past few years, I have been especially aware of that at Acoustical Society of America meetings. The French always have a fairly large number of participants and speakers at these meetings, and there have been an increasing number of papers by French authors in Journal of the Acoustical Society of America (JASA). These developments are most probably because English will be the predominant language within the EC scientific community.

Because the European constituency is very concerned about the protection of the environment (witness the very strong showing by the Green Parties of Europe in the recent EC elections for the European Parliament), I think that European researchers in Acoustics will be comfortably supported in the next decade. All the universities and laboratories that I have visited over the last 18 months have indicated that they are or expect to shortly be involved in EC collaborative projects. Professor L. Bjorno, Technical University of Denmark, reports that close to 50 percent of his research money has been generated through EC-type contracts. The Acoustics group at the Technical University of Compiegne also has several EC-related contracts especially in the area of developing

sound radiation computational models for the automobile industry. The Fraunhofer Institute for Building Acoustics in Stuttgart has three projects involving improved acoustical measurement techniques with other EC countries including France, Germany, Switzerland, the Netherlands, and Spain.

In 1988, the EC Council of [Research] Ministers approved 35 million ECUs (about \$41 million) for pilot research program in aeronautics R&D. There are four categories of research of which acoustics is one, covering such wide areas as noise source identification, acoustical fatigue, and development of acoustical simulation models for response calculations under acoustical loading. The availability of such large amounts of funds will certainly attract established investigators and give impetus to new research programs.

I see the future European climate to be very receptive to the further development of acoustics, especially as it impacts on the environmental quality of life.

INFORMATION TECHNOLOGY

U.S. Marketing in Europe in the Single Market of 1992 in Computers, Telecommunications, and Microelectronics

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for Industrial Assessment in Computer Science and Telecommunications.

Introduction

By the end of 1992, the EC intends to remove obstacles to the free movement of goods, services, personnel, and finances within the 12 EC countries. The result will be a single market of 320 million consumers worth about \$4 trillion/year. The impact of this change will be felt by European manufacturers, consumers, and service providers and also American and other non-European manufacturers and service providers.

The importance of this market to American companies is enormous. American companies exported about \$75 billion in goods and services to the EC in 1988, and even more striking were the sales of affiliates of American companies located in Europe in 1988--\$550 billion.

Impact on the Europeans

In the mid-1980s in computing and telecommunications, the European industries began a process of change. Part of this change came as a result of the merging of these two industries, made feasible through developments in microelectronics. These developments made possible the transmission and switching in digital form of voice, images, and data. Developments in fiber optics allowed for large increases in transmission capacity and speed. One result was a great increase in computer networks and an increased demand for intelligent terminals, personal computers, and workstations. Since equipment from different manufacturers is needed to communicate, the need for standards in a variety of areas became more apparent and urgent.

Another factor was the gradual recognition that more competition, particularly in the telecommunications industry, might lead to greater innovation in providing products and services. In late 1984, the U.K. introduced both competition in basic telecommunications services in the public service and in telecommunications equipment to the providers of the service. The British Government sold 51 percent of British Telecom to private investors and licensed Mercury, a subsidiary of the Cable and Wireless Company, to compete with British Telecom. This has been followed by substantially opening the market for customer premises equipment and value-added services to be provided on the public network. Most other EC members have taken some steps in the same direction. As of January 1989, both Spain's and the Netherlands' main operating companies for the provision of telecommunications services became private (although still government-owned). At the same time, the market for customer premises equipment and for providing value-added services was opened up to competition. At the end of 1989, the Federal Republic of Germany took similar steps.

A third factor in these changes was the renewed interest on the part of the EC in carrying out the project laid down by the 1957 Treaty of Rome. This treaty committed the EC members to eliminating tariffs among themselves and to erecting a common external tariff, thus forming a common market.

The launching of the ESPRIT in January 1984 was the beginning of the acceleration of change in preparation for the Single Market. This program was envisaged as a 10-year program consisting of two 5-year phases--ESPRIT I and ESPRIT II. The ESPRIT I's funding was 1.5 billion ECU; the EC supplied one half, participating companies supplied the rest. The ESPRIT's aim was to provide the European IT industry with the technology to enable it to become and remain competitive in world markets in the 1990s.

At the time the ESPRIT program began, the EC was concerned about its dependence on imports in the IT industry. From a trade surplus in this industry in 1975, the EC had reached a deficit of \$5 billion in 1980. By 1984, the deficit was worse and deterioration continued until in 1987 the deficit in the entire electronics industry had reached \$21.9 billion. Computers were responsible for \$12 billion of this deficit, but telecommunications still provided a positive balance of nearly \$1 billion in 1987.

In January 1988, ESPRIT was followed by the RACE program. This 5-year program was funded at 550 million ECUs. The goal of the RACE program is to prepare Europe for the introduction of IBC, taking into account the evolving ISDN. The plan is for EC-wide services by 1995.

The EUREKA grew out of a proposal made in 1985 by President Mitterand of France. The members are the

12 members of the EC, the Commission itself, and 7 EFTA countries. As of the end of 1989, there were 291 announced projects in the EUREKA program, of which about 25 percent were in IT. The estimated cost of the 291 programs over their lifetimes is about 7 billion ECUs. Prominent among its programs are the High Definition Television (HDTV) and the JESSI programs. The JESSI program is for developing the technology to produce memories and logic using 0.3 micron feature size by 1995. This should permit 64-megabit dynamic random access memory (DRAM) chips to be manufactured, and allow integration of over one hundred million functions on a chip.

The high cost in money and personnel for development in these high-technology industries increases the interest of EC members in participation in European programs like the above. The cost has also led to mergers, joint ventures, and collaborations outside of the EC initiatives (see Table 20).

Table 20. Mergers, Joint Ventures, and Collaborations Outside of EC Initiatives

- Philips and Siemens collaborated in the Mega Project, which led to developing and producing 4-megabit DRAMs; the project is also a foundation on which to build the JESSI program
- Siemens bought a controlling interest in Nixdorf, thus bringing together the two largest German computer companies
- Standard Telephone and Cables (STC), U.K., combined with International Computers Limited (ICL), thus bringing together the two merging technologies
- British General Electric Company (GEC) joined with Siemens to purchase Plessey, the British telecommunications manufacturer
- Siemens, Alcatel, France; Italtel, Italy; and Plessey are planning the next generation of digital switching equipment.

There have been instances of European and American companies working together in a variety of arrangements. These will be further discussed in the next section of this report.

After 1992, European companies will be less able to count on their own national markets for favored treatment by governments, service companies, and consumers. Consequently, they must seek business outside of their own respective countries. They will compete with all the other European companies more-or-less equally as well as with foreign competitors.

In addition to the high cost of development mentioned above, this highly competitive environment will also be a major factor in forcing mergers and joint ventures between companies, and particularly in small- and medium-sized companies. There are now around 10 digital switching equipment manufacturers in Europe. The de-

velopment costs run into billions of dollars. Soon, small- and medium-sized companies will be unable to afford the development costs. The result in Europe will be fewer suppliers, but those that remain will be larger and stronger.

European service providers, like telephone and telecommunications operating companies, will have a wider choice of products in fact rather than in theory. Thus, they should be able to have the most advanced equipment available in the world and, consequently, be able to provide better service. This, in turn, should benefit the consumer in terms of service quality and cost.

Impact on American Suppliers

As mentioned earlier, the European market is important to American business. The U.S. sales in Europe are three times U.S. sales in Canada, and four times U.S. sales in Japan. Particularly, U.S. computer companies have very large investments in R&D in Europe. For example, for more than 70 years, IBM has been a major factor in research, development, manufacturing, and marketing in Europe. Many others, including Digital Equipment Corporation, Hewlett-Packard, UNISYS, Cray, and others have been in Europe for a decade or more.

In computer systems alone, Europe (EC and EFTA countries) represents about 28 percent of the world market of more than \$250 billion. According to Datamation, of the top 10 suppliers of IT equipment in Europe, four are American and six are European. The IBM has the largest share of the European market--about 25 percent. However, in growth of market for 1984-1987, the top three in growth were European-Nixdorf, Olivetti, and Philips. As mentioned above, Nixdorf has been bought by Siemens, the company that ranked seventh in growth during this period.

In the European market in software, the U.S. is the dominant supplier of packaged software, but European software companies are becoming a major force in customized software. European telecommunications equipment suppliers remain dominant.

In microelectronics, according to Dataquest, Europe represented 37 percent of the \$36-billion world market in 1987. Europe supplied only 11 percent of the world market. Concern about this drop from 15 percent in 1980 is largely responsible for the Mega Project of Siemens and Philips and the more recent JESSI program. At present, the U.S. suppliers and the European suppliers share about equally in the European market for microelectronics. Japanese suppliers are third with around 20 percent of the market.

American goods and services suppliers should benefit in many ways from the Single European Market. They will need to manufacture to a single set of specifications for a particular product to be sold in Europe, rather than

up to 12 at the present time. The movement of parts, goods, and services from one country to another will be much easier and probably less expensive for both European and foreign companies. Marketing and service will also be much easier because of less product variability.

The EC's approach to standards may cause difficulty for non-European companies. Over 100,000 industrial standards and technical regulations are in force in the EC's members today. In its Cassis de Dijon decision in 1979, the European Court of Justice ruled that products that meet requirements in one EC member can circulate freely in all other members. Thus, an American company that previously had to produce to 12 different standards or regulations may soon be able to produce to one set of European standards.

The EC has contracted with European regional standards-setting bodies, mainly the European Committee for Standards (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), to develop Europe-wide voluntary standards that give the essential standards requirements. Conformance to these standards provides manufacturers with a way of demonstrating compliance with the essential requirements. Regional standards to replace thousands of differing national standards will ultimately be developed by these bodies; the ultimate aim is for EC-wide standards. The EC will establish a system for testing and certification to ensure conformance with essential requirements and to provide incentives for adhering to voluntary standards.

A problem for U.S. exporters is their lack of formal channels for direct influence in the proposal stage of the EC directives. Also, in the preparation of voluntary standards, U.S. standards organizations have no standing at CEN/CENELEC, even as observers. Thus, U.S. manufacturers have a very short leadtime to change their product designs and testing procedures. In a few cases, EC standards are different from or incompatible with U.S. standards.

Consider, for example, the directive on standardization in the field of IT and telecommunications (see Table 21).

In most of the world, including the U.S., developing standards for the IT industry has been left entirely to the private sector. There are no U.S. Government regulations similar to this directive. However, the General Services Administration's procurement policy requires that products be compatible with the Open Systems Interconnection (OSI) Reference Model, a set of standards used to assure users of system interoperability.

Decisions taken under this directive will affect U.S. manufacturers of computer equipment and peripherals, ASIC, data communications products and software, telecommunications products used for computer communications, and providers of data processing and value-added network services. This directive affects a

broader range of U.S. companies than most EC technology-related actions.

**Table 21. CEN/CENELEC
Information Technology/Telecommunications
Standards**

- Determine priority standardization requirements through biannual meetings of two senior officials groups in IT and telecommunications
- Request European standards institutions and specialized technical bodies in the IT and telecommunications sectors to establish European standards
- Base European prestandards or telecommunications functional specifications based on international standards to the extent possible
- Facilitate the application of these standards and specifications by coordinating EC members' verification and certification of standards conformity for products and services
- Refer to European standards, European prestandards, and international standards in public procurement orders of EC members valued at 100,000 ECU or more.

A serious problem for U.S. manufacturers could be the time of availability of product specifications and testing procedures. If European companies get this information substantially ahead of American and other non-European companies, then the American and other non-European companies will be disadvantaged.

The European companies with whom Americans are competing will, in general, be bigger with more resources for R&D, manufacturing, marketing, and service. European companies will also benefit from total European R&D efforts like ESPRIT, RACE, and EUREKA. Also, some EC directives may hinder American and other non-European suppliers. For example, if the directives favor products manufactured in Europe, American suppliers may need to establish more manufacturing facilities in Europe. American computer companies are already manufacturing in Europe much of the equipment that they sell in Europe, and in many cases they are accomplishing the R&D in Europe that supports the product manufacturing. This is true to a lesser degree in telecommunications and microelectronics.

The Treaty of Rome, Article 58, entitles all firms organized under the law of an EC member to be treated as European firms. Consequently, U.S. companies in Europe should be treated like European firms. However, local content provisions exist in government procurement

directives for telecommunications products as well as some others.

In order to improve their ability to carry on business in Europe, a number of American companies, particularly in telecommunications, are establishing partnerships, joint ventures, or other associations with European companies (see Table 22).

**Table 22. Telecommunications
Partnerships and Joint Ventures**

- AT&T and Philips, the Netherlands, formed a joint subsidiary for European operations
- AT&T purchased a substantial share in Olivetti, Italy, and the two companies are collaborating on the sale of their respective products in their respective countries
- AT&T and Italtel, Italy, are collaborating in R&D and marketing.

However, such joint work is not constrained to telecommunications alone. Recently, IBM and Siemens announced an agreement to jointly develop a new generation of computer memory chips. They will develop 64-million bit DRAM chips. In another recent announcement, NBC, a division of RCA Corporation, and Thomson Consumer Electronics, Inc., France, who have been working together, said that they are joining forces with North American Philips Corporation on HDTV development.

The U.S. companies will be better able to compete, particularly after 1992, if they have an established presence in Europe. This should include manufacturing and ideally also R&D. In many cases, it will also be most useful to have a European partner or collaborator. A big factor in the success of American computer companies in Europe has been their established facilities for development and manufacturing in Europe. American telecommunications companies and microelectronics companies will be well-advised to follow this example.

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MATERIALS SCIENCE

The Impact of 1992 on Materials Science

by Michael J. Koczak, the Liaison Scientist for Materials for the Office of Naval Research European Office. Dr. Koczak is on sabbatical leave from Drexel University, Philadelphia, Pennsylvania, where he is a Professor of Materials Engineering.

Background - European Cooperation in Research

The impact of the 1992 EEC on materials research has had overtures with several multinational research programs. Previous cooperation in research activities has created European programs in the aerospace commercial sector with the development of the Airbus, Ariane, and Hermes. In addition, other multinational programs; i.e., EEC - BRITE, EURAM; EUREKA, have been generated in order to accelerate development of advanced technologies and to create original devices for commercialization. A first tier of programs was initiated during 1984-1987, a second "Program-Cadre" for the 1987-1991 timeframe and a third in 1990. These cooperative, interdisciplinary programs seek to bring together research institutes, academic laboratories, and industrial partners with a cooperative, jointly funded and highly leveraged research program. The creative and evolutionary nature of these programs has catalyzed several research efforts in the materials science and has forged EC links throughout the manufacturing sector. The research programs will be highlighted and future developments assessed with regard to their repercussions on international research collaboration.

This development of materials science in the EEC is becoming united with an interlocking network of university, industry, and government cooperation. The form of cooperation can be viewed in two forms: the development of a cooperative research funding and manufacturing base, also the more unified cooperation of the materials' societies. In the former category, BRITE was spawned in 1985, a second round of projects being generated in 1988 and a third in 1990. Specifically in materials science, several technical areas have been targeted with a EURAM program. Fields of study within the 1986-1989 timeframe concerned are:

- Primary raw materials
- Secondary raw materials
- Wood as a renewable resource

● Advanced materials (EURAM)

Under the EURAM programs, several priority themes have been selected in four major technical areas with specific priority themes (see Table 23 and additional reading).

Table 23. EURAM Major Technical Areas

Advanced Materials Technologies

- Metallic materials and metallic matrix composites
- Materials for magnetic, optical, electrical, and superconducting applications
- High temperature nonmetallic materials
- Polymers and organic matrix composites
- Materials for specialized applications; e.g., biomaterials, packaging, and civil engineering materials

Design Methodology and Assurance for Products and Processes

- Quality reliability and maintainability in industry
- Process and product assurance

Application of Manufacturing Technologies

- Advanced manufacturing practices for specialized industrial purposes; e.g., tooling, design methodology, integrated design, and production
- Manufacturing processes for flexible materials; e.g., clothing, footwear, composite, and packaging materials

Technologies for Manufacturing Processes

- Surface techniques
- Shaping assembly and joining
- Chemical processes; e.g., optimization of reactions, selectivity, membranes, and catalysis

In the realm of metallic alloys, emphasis is placed upon Al, Ti, Mg alloys, electrical contact and magnetic materials, coatings, tooling materials, and development of thin wall castings. For engineering ceramics, the studies include property optimization, metal ceramic interfaces, ceramic composites, and high-temperature behavior. Within the area of composite materials, studies on metal and organic systems have been addressed.

A second research effort entitled BRITE has an initial time span from 1985-1989 with the application of manufacturing technologies to several industries; e.g., aerospace, automotive, chemistry, metals, and textile. There are materials aspects to the BRITE program that incorporate polymers and composites production techniques for flexible products. Also, concerns include reliability, wear, membrane science, CAD/CAM laser technology, and joining techniques.

In addition to the BRITE/EURAM programs, co-operation between European laboratories has been spurred by the STIMULATION program for combining research capabilities of two or more laboratories. In addition, the European COST program was established. A JRC program has established concerted programs at four locations in the materials area; i.e., JRC Geel, JRC Ispra, JRC Karlsruhe, and JRC Patten (see ESNIB 89-02).

In a separate EUREKA program, there are several materials-related EUREKA programs with joint multinational participation spanning an initial 2- to 5-year time period (see Table 24). Emphasis placed upon the development of improved materials; e.g., advanced composites, ceramics, continuous casting of sheet steel and aluminum, and materials for transportation systems. Apart from the research activities, several education programs are actively being implemented and are highlighted in Table 25.

Summary

At this point, Europe is orchestrating a union of educational, corporate, and government research centers as well as technical societies motivated by the 1992 deadline. Although there has been cooperation in the past, a realization that the union is nearing has catalyzed more vigorous activities. In certain cases, corporate mergers of European companies are creating facilities and expertise comparable to research laboratories abroad: e.g., GEC, Siemens, and Plessey; MBB and Mercedes Benz. As a result, the corporations appear to be enthusiastically seeking international, particularly European, partnerships to create and/or expand their position in the EEC.

The materials position and research strategy of the U.S. has apparently not crystallized. The choices are: (1) ignore the situation and carry on business as usual; (2) allow the major multinational corporations to develop and strengthen their linkages to the EEC research community; or (3) forge research programs to the manufacturing and market sectors, establish contacts, reinforce the existing ties, and develop a joint research and development linkage to the EEC programs.

Via joint partnerships in research and materials development, a quid pro quo can be established with the EEC. The ties can be most easily established at four parallel levels: government/government, university/university, defense agency/agency, and industry/industry. Although more difficult, the cross linkages; e.g., defense

Table 24. Materials-Related EUREKA Programs

Research Projects	European Participants	Years
Performance thermo-plastic composites	Oy partek (Fin), Recticel (B)	2
Coating technics for advanced technologies	Coat (S), Leybold Heraeus (RFA), Volvo (S), Flakt (S), Inco (GB)	4,5
Membranes	Lyonnais des Eaux, Degremont (F), De Danske Sukkerfabriken (DK)	6
Amorphous silicon	Solems (F), MBB (RFA)	5
Ceramic precursors	Menotherm (A), Titaceram (B)	3
Carmat 2000 - Car structures using new materials	Peugeot SA(F), ICI (GB), BASF (RFA), DSM (H), Vitrotex, Italia (I), Cristalleria, Espanola (E)	5
Development of new materials for car engines (CMC,MCC)	Pechiney (F), Fiat (I)	5
Diane - Automatic integrated system for neutronography	Sodern (f), Dornier (RFA), Sener (E)	5
Use of ceramics in gas turbines. (Industrial 5MW, marine 2MW)	SEP (F), Volvo (S), Alfa Romeo (I)	5
Use of Ceramics in diesel engines (SIC-SIC)	SEP (F), Man (RFA)	5
Development of softwares for injection molding thermoplastic parts	Royal Institute of Technology (S), Center for Industrial Research (N)	5
Light materials for transport systems	Pechiney (F), VAW (RFA)	4
Mineral membranes for biological fermentation	SFEC (F), Farmitalia (I)	4
Gas turbine for automotive applications	Peugeot, Garrett, Ceramiques techniques, ONERA, Microturbo (F), Daimler Benz, BMW, Hoechst Ceramtec Bayer CFI, Volkswagon, Garrett GMBH (RFA), Volvo (S)	4
Structural ceramics for burners with heat exchangers	GDF, ceramiques et composites, Auburtin (F), Kroms Chroder (RFA), Hingassa (E)	5
Continuous casting of very thin metallic (aluminum, iron) bands	Pechiney, Irsid (F), Thyssen Stahl (RFA)	6
Polymeric fibers for medical applications, reinforced concrete, and organic matrix composites	Denmark, Finland	5

Source D. Cotto, Embassy of France

agency/university and /industry, certainly should be pursued and should provide for a more international and talented research base and facilities. The materials research field can serve as a model for this program, since the research direction at the basic research level is clear, the community is relatively small, and the contacts well established.

From a corporate market perspective, a three- or four-fold competition is foreseen between in the U.S., EEC, Japan, and the NICs. The multinational companies; e.g., IBM, DuPont, already have a presence in Europe and probably feel secure in their research and marketing positions and will not be excluded from the 1992 developments. Companies that have marketed in the U.S. and Europe but without European domestic content are in peril, i.e., the range of companies in the small- to middle-size company that cannot afford a position in Europe. These innovative companies have a market potential should seek joint manufacturing and research linkages.

Further information of the BRITE/EURAM programs can be obtained at no cost from the European Communities Offices in:

Washington

2100 M Street, NW (Suite 707), Washington, D.C.
20037, telephone (202) 862-9500, telex 64 215
EURCOM NW, telefax 429-1768

New York

Suboffice of the Washington Office, 3 Dag Hammarskjöld Plaza, 305 East 47th Street, New York, NY
10017, telephone (212) 371-3804, telex 012 396
EURCOM NY, telefax 758-2718

Brussels

Programme Manager: Willem van der Eijk, Production and Materials Technology, telephone Brussels, Belgium, 235.59.60

Joseph Wurm, Materials Research, telephone Brussels, Belgium, 235.52.90

Herbert Allgeier, Aeronautics R&D, telephone Brussels, Belgium, 235.40.55.

Commission of The European Communities, Directorate General for Sciences, BRITE/EURAM Program, Research and Development XII/C, 200 Rue de la Loi, B-1049 Brussels, Belgium, Tel: 32-2-235-1111.

Reference

ESNIB 89-02:39 (1989).

Additional Reading

Available from the above EC Community Offices:

XII/289/88-EN Division C-4, Materials Technology EURAM (1986-1989) Project Synopsis

BRITE: Basic Research in Industrial Technologies in Europe (Project Synopses 1985 and 1987)

Table 25. EC Educational Programs

Program	Participation	Objective
PETRA	Young people in vocational training following full-time compulsory education. 154 training initiatives in 1989. 200 youth projects.	Support, with a community added-value, the implementation of the Council decision of the vocational training of young people.
IRIS	Women in vocational training. 71 projects in 1989.	Develop the access of women to vocational training.
CEDEFOP	Decision makers, practitioners, social partners involved in initial and continuing vocational training.	To assist the commission in the promotion and development of vocational training and in-service training.
EUROTECNET	Young people and staff of enterprises in training. 135 demonstration projects in 1989.	Dissemination of innovations in the area linked to new technologies.
EURYDICE	Education officials.	Develop information on the education systems and on EC activities in the education field.
ARION	Education policy-makers and experts. 3,200 study visits since 1978.	Improve mutual understanding of the education system.
LINGUA	Pupils and teachers from secondary and higher education.	Improve language training for the citizens of the EC.
Education of Migrant Workers' Children	Primary and secondary schools with migrant children. 15 pilot projects in 1988.	Improve the integration of migrant children at all levels of the education systems.
ERASMUS	Students in higher education. Participation of 4,300 students and 1,500 higher education institutions in the first phase.	Increase the mobility of students in higher education in the EC and add a European dimension to their initial training.
COMETT	Students in higher education and staff from enterprises participating in 1987/1988. 1,320 projects and 2,400 students.	Stimulate university-industry cooperation in order to improve high-level training linked to new technologies.
Youth for Europe	Young people from 15 to 25 years old. Participation in the first phase: 80,000.	Improve, develop, and diversify young peoples' exchanges in the EC.
Exchanges of Young Workers	Young workers or job seekers of 18 to 28 years old. Participation in 1987/1988: 7,000.	Offer training or work experience for young people in another member state.

Source: the International Herald Tribune, Oct. 4, 1989.

MATHEMATICS

Academic Mathematics and 1992

by Robert D. Ryan, a mathematician currently serving as a Liaison Scientist for Mathematics and Computer Science in Europe and the Middle East for the Office of Naval Research European Office. Mr. Ryan is on leave from the Office of Naval Research Arlington, Virginia, where he is Director of the Special Programs Office.

Introduction

The thrust of 1992 is the implementation of the Single European Act (Act), which has as its main focus a frontier-free Europe--physical frontiers open to the free movement of goods and people and technical barriers open to the movement of capital and financial services. The Act is an economic document, and those assigned the task of implementation--The Commission of the European Communities (Commission)--speak primarily in economic terms. What will this mean for mathematics and mathematicians in terms of jobs and research support?

Background

The research model being discussed here is the old-fashioned one of the individual researcher in an academic setting, working alone or with a few graduate students. I believe it is worth considering this situation for at least two reasons: (1) other articles in this volume address different models of scientific activity, and (2) the model I describe continues to hold a central place in research and education. Most mathematics research is an individual activity. Publications by individuals far outnumber joint papers, and although there are cooperative efforts, mathematics has not become a team sport. Although this note is about mathematics and mathematicians, many of the comments apply equally well to sciences and scientists that operate at the basic end of the R&D spectrum; e.g., computer scientists working on the foundations of the subject. These researchers and their sciences are characterized by individual activity, by the lack of a need for expensive capital equipment (aside from access to computing resources), and by the fact of university employment.

Jobs

The lack of academic positions in their home country is the number one problem facing many young European mathematicians. All too often an aspiring academic faces

the choice of an academic position in the U.S. or Canada, or a nonacademic job at home. In choosing the former, it is often with the hope of building a research reputation and being well positioned when a job at home becomes available. Taking a nonacademic job can lead away from academia, particularly in those academic systems known for their rigidity--the source of the original problem.

The academics with whom I have discussed this issue believe that the advent of 1992, in spite of advertised claims of mobility, will change the situation very little. The Act's goals for freedom of movement of workers and members of professions, and mutual recognition of degrees and professional qualifications, combined with the goal on access to employment in the public sector--including teaching in public establishments--hold out the potential for a more open market in academic positions. Unfortunately, the success of the Act will not create academic positions directly, but it may provide easier access to those that do become available. On the other hand, mathematicians have always been quite mobile both within Europe and between Europe and the U.S. or Canada.

The implementation of the Act holds the potential for the creation of more academic positions in mathematics and the other basic sciences. If the EC and its members are to strengthen their competitiveness, the education systems must have as a goal the training of more scientists and engineers, with a corollary of more teaching and research positions in these areas. However, it must be recognized that issues surrounding higher education touch upon national policies, and these issues are even more sensitive than national policies for R&D, an area where the Commission has noted inadequate coordination.

Research Support

Research is the third largest area of EC spending after farming and regional development aid. The EC Council of Research Ministers (Council) has approved 5.7 billion

ECU for the next 5-year **Framework** program. This combines with 3.1 billion ECU remaining from the second **Framework** for a total 8.8 billion ECU for 1990-1994. The details of how this money is to be spent will not be known until after negotiations between the Council and the European Parliament, but all indications point toward more support for basic and precompetitive research. There is also a move toward more cooperation with other non-EC countries including Eastern Europe. In fact, the Council approved a study to investigate the terms of closer cooperation with the countries of Eastern Europe in the area of research. I believe that this bodes well for increased support for mathematics, but at this time it is impossible to know how much will flow that way. Even after the budget is completed, it is difficult to know exactly how much is being spent on basic research in all of the sciences; localizing this to mathematics is a research problem.

The consensus among the EC watchers is that EC support for basic mathematics research, while relatively small, is growing. The current SCIENCE program contains specific projects in mathematics. If one backs away from looking for funding specifically labeled mathematics, it is clear that other EC support is having an impact on areas of basic mathematics research. For example, part of the ESPRIT II funding allocated to basic research

is supporting good mathematics within the context of computer science. To the extent that national support for basic research declines, the EC money takes on increased significance in the total funding picture for mathematics. Nevertheless, the thrust of EC funding for research peaks somewhere to the right of basic mathematics on the R&D scale as portrayed in our original model. Couple this with the fact that a significant segment of the academic mathematics community is ill-disposed toward collaborative research as defined by the EC, and one concludes that, at least in the near time, most support will continue to come from national sources.

Summary

The implementation of the Act will probably not have a direct and immediate impact on academic jobs for mathematicians; on a longer scale, a successful EC will need more scientists, including mathematicians. Here it is important to keep in mind that while academic mathematics continues to play an indispensable role in research and education, today it represents only a subset of mathematical activity. If one examines the employment of mathematics and mathematicians in other settings, associated with those technologies selected as important to the EC, then the impact of EC support is not insignificant.

MATHEMATICS AND SCIENTIFIC COMPUTING

The European Community and 1992 Impact on Mathematics and Scientific Computing

by Richard Franke. Dr Franke was the Liaison Scientist for Mathematics and Scientific Computing in Europe and the Middle East for the Office of Naval Research European Office. In September 1989, he returned to the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics.

In the field of scientific computing, the precise impact of the various research programs of the EC, such as EUREKA and ESPRIT, is difficult to gauge. I have talked to a several researchers in various areas who are supported by funds from EC-supported projects.

The ESPRIT supports work at the Technical University of Catalonia, Barcelona, Spain, on image processing, especially tracking particular objects on video images. The applications include detection of defective products on moving conveyer belts, implementation of systems to track eye movements for handicapped persons to use as

a computer input device, and automatic cultivation and harvesting of crops.

The ESA supports work at several universities. Model development and large-scale computational work on fluid dynamics is supported at Kaiserslautern University, Kaiserslautern, FRG; Pavia University, Pavia, Italy, and at places I have not visited. The ESA supported other work related to the ill-fated HIPPARCOS satellite telescope, particularly the high-precision calculation of the parallaxes and proper motions of stars for a star catalog. While the satellite is now in orbit, the rocket engine for the final boost to geostationary orbit has failed, severely curtailing if not ending the usefulness of the telescope.

According to Dr. Jean-François Omnes of the EEC Information Technologies - ESPRIT organization, European market share in IT is increasing. Investment by IT companies in Europe is increasing, and furthermore, faster than in either the U.S. or Japan. How much of this is because of the impetus of ESPRIT is speculative, but no doubt it is important.

Along with investment of various research programs of the EC, I think a very important factor is the new mood that is being engendered (I add that this is not universal among the persons I have talked to, however) by the approach of 1992. I think this new mood is typified by the European Consortium for Mathematics in Industry (ECMI). This organization is a few years old and was formed to foster communication and cooperation between academic and industrial organizations (see *ESNIB* 89-01:28). The members of ECMI are anxious to work on problems (with mathematical content) of interest to industry. In addition, some member educational institutions have educational programs emphasizing multicountry cooperation--some study time being required to be spent in another country before a degree is

awarded. Because of the varying areas of mathematical expertise in different European countries, this program can be particularly fruitful. I believe these sorts of programs will increase the number of students opting for study (at the graduate or postgraduate level) in another European country instead of going to the U.S. as they might have done previously.

Another institution that is a precursor of the cooperation to come is the European Centre for Research and Advanced Training in Scientific Computation at Toulouse, France (see *ESNIB* 89-07:42). While the initial impetus for the establishment of the facility and the sponsorship was from within France, the scientists working there are an international group (from several European countries, as well as the U.S.). As the center expands it is anticipated they will become more international, and especially more European. Because it is a training facility with no permanent scientific staff, the students and advisors will return to their own or other countries with a broader view of international cooperation.

The impact of the removal of emigration barriers between the European countries may have drastic effects, but at the level of scientific research and university teaching that is hard to assess. For example, university professors seem to be significantly lower paid in the U.K. than in the FRG. On the other hand, this is unlikely to cause an exodus to Germany since (in mathematics, at least) there are already more persons looking for university jobs in Germany than there are positions available.

References

- ESNIB* 89-01:28 (1989).
- ESNIB* 89-07:42 (1989).

SOLID-STATE PHYSICS

Solid-State and Semiconductor Research Impact of Europe 1992

by Dean L. Mitchell, the Liaison Scientist for Solid-State Physics in Europe and the Middle East for the Office of Naval Research European Office.

The modes and directions for scientific research in western Europe are being increasingly influenced by the EC. Until recently, support provided by the EC programs was concentrated in trade and agriculture. In fact, a major fraction of the EC budget is still devoted to agricultural subsidies to the member nations. However,

funding for scientific and technological programs is increasing with potential for further increases as agricultural subsidies decline. On an absolute scale, the EC-funded scientific research and education programs account for about one billion ECU (\$1.1 billion) per year compared with total public and private sector support for

civilian R&D in the individual EC countries which totals about 50 billion ECU (\$55 billion) per year.

The ECR&D programs that support research in solid-state physics and electronic materials, to any significant degree, are BRITE/EURAM, ESPRIT, and SCIENCE. The BRITE program was initiated in 1985 as a 4-year program to modernize European industry by introducing advanced processing technologies and developing new materials. The EURAM and BRITE programs on advanced materials were combined and the extension of the two programs is being funded at a level of 440 million ECU (\$484 million) for 1989-1992. As with other EC programs, the funding levels are for the life of the project rather than annual levels, as in the U.S. The 3-year first phase was completed in 1989 and has since been renewed for an additional 2 1/2 years. Support of basic research is permitted, up to 7 percent of the total, where deficiencies in the research base are evident. The proposed BRITE/EURAM II program will cover shared-cost research on advanced materials as well as design methodologies and manufacturing processes.

The ESPRIT is the most well-known and successful of the EC programs; it also receives the largest portion of EC R&D funding. The 5-year Phase I program was just completed and is considered a success in terms of the research results that have been converted into technology. Phase I was allocated 1.5 billion ECU (\$1.65 billion) of which about one-third is supported research, mainly applied, in semiconductors and solid-state physics. Phase II (1987-1992) has been approved at 1.6 billion ECU (\$1.75 billion) which requires matched funding for a 3.2-billion ECU total program.

The ESPRIT II program is expected to provide about 30 percent of the total European investment in precompetitive R&D for information technology. The ESPRIT II is the significant source of research funds for universities and institutes involved in research on semiconductors, superconductors, and device physics. Table 26 provides the solid-state microelectronic working groups (acronyms in parenthesis).

The EC-supported SCIENCE program (see page 37), formerly named STIMULATION, covers a range of activities concerned with improving the infrastructure for multinational research cooperation by support of conferences and courses in advanced scientific and technological areas (10 percent); "twinning grants" (exchange of researchers) from laboratories in at least two countries working on a common topic (60 percent); and "operations grants" for targeted research by associations of several laboratories (30 percent). The size of the science budget is relatively small, 167 million ECU (\$184 million) for 1988-1992; however, it is a major source of support for research-related activities, such as advanced courses and travel, which are difficult to fund otherwise. Also, the

SCIENCE funds are not required to have industrial participation that is required in other programs.

Although not directly administered by the EC, projects in the EUREKA program are closely coordinated with the related EC projects. The EC also participates in, and contributes funds to, EUREKA projects on the same basis as any member nation. In 1985, Francois Mitterand, Premier of France, instigated the program to provide an organization both to stimulate and coordinate collaborative research projects likely to enhance Europe's competitive position in world markets. The projects selected are market-driven and are primarily aimed at developing high-technology products and services. Priorities include advanced computer hardware, robotics, telecommunications, bioengineering, and advanced materials; e.g., ceramic turbines. The research tends to be highly focused and oriented toward applications. Universities and research institutes participate but the

Table 26. Solid-State Microelectronic Working Groups

- High Temperature Superconductivity: Concepts Models and Methods (HTSC THEORY)
- Electric Fluctuation and Noise in Advanced Microelectronics, 2-D Gas and Low Temperature Devices (NOISE)
- Heterostructures of Semiconducting Silicides on Silicon Application to Si-Compatible Opto-Electronic Devices (HESS\LSIL)
- Possible Mechanisms for High- T_c Superconductivity and Phenomenological Approaches (MESH)
- Performances and Physical Limits of Heterostructure Field-Effect Transistors (NANOFET)
- Lateral Microstructures-Fabrication, Low Dimensionality Effects and Application & III-V Devices (LATMIC)
- Low Dimensionality Structure for Future Quantum Semiconducting Devices
- Programme for MOS Processing Technology (PROMPT)
- Conducting Organic Material as Molecular Components for Microelectronics (MOLCOM)
- Nanostructures for Semiconductor Devices (NANSDEV)
- Study of the Influence of Impurities on the Properties of High T_c Superconductors (DIRTYSUPRA)
- Limiting factors in III-V Semiconductor Devices Due to Donor-Related Deep States (DX Centres)
- Ultrathin Si\Ge Superlattices
- Investigation of Optical Probe Techniques for Interface Characterization (EPIOPTICS)
- Foundations of Optoelectronic Computers (FOCUS)
- Quantum Noise Reduction in Optical Systems (NOROS)
- ESPRIT Optical Computing (EOC)
- Structure and Transport Properties of Organic Low-Dimensional Systems for Application to IT (OLDS)
- Disorder and Electrical Properties in Silicon Oxynitrides
- Lattice Dynamics of High T_c Single Crystal Superconductors (SUPRADYNAMICS)

research is highly focused and research directions and schedules are dictated by the industrial partners who supply 50 percent of the funds.

The JESSI program is a new EUREKA program established in 1989. The program was initiated by a consortium of SGS-Thomson, Philips, and Siemens who are the main partners, and its main objective is the establishment of Europe as a major supplier of silicon computer chips by 1994. The intermediate goal is to develop medium-scale integrated circuits (ICs) by 1991-1992; the end goal is to market advanced ICs by 1995-1996. A total budget of 20 billion FF (\$6.2 billion) will be spent over the 7-year lifetime of the project with costs split equally between the industrial partners and member nations.

Although the level of funding for the EC programs described above is low on an absolute basis, accounting for only 2 percent of the total R&D support, the leverage of EC support is considerable because of the way European research support is structured. Traditional European support modes differ from the normal support modes for U.S. research. In the past, salary support for established research investigators in European universities or research institutes was usually provided through the core support of the researcher's institution. Once established, positions were rarely abolished. Likewise, graduate students usually were supported by educational grants and were more-or-less free to pick projects they wished to work on. Thus, established research groups with well-instrumented laboratories were able to carry out active research programs without grants and only required extra funding in order to cover unusual operating expenses, special equipment, or major facilities.

In the past, these funds for specialized equipment and operations were provided through the educational support channels or by the national research support agencies with minimal proposal and report requirements. These traditional funding sources are not able to keep up with the needs for increasingly sophisticated and expensive research equipment and facilities. The EC programs provide an alternate source for such funding and EC grants are being used both to supplement normal core funding and to initiate new research directions. The proposals that are required to obtain EC funds commit a level of effort significantly in excess of that provided by the EC funding with the remainder coming from the core. Hence, the EC funding tends to influence the research directions and style of research to a much greater degree than the raw numbers would indicate.

In visits to laboratories in France, the Netherlands, and the U.K., I encountered several projects where the EC funding had a significant effect on the scale and direction of the in-house research. At the Laboratoire de Physique des Solides, an associated laboratory of the Centre National de la Recherche Scientifique (CNRS) at the University of Paris VI, Professor M. Balkanski has long

headed a group that is recognized internationally for its basic studies of lattice dynamics and the optical properties of solids. Over the past several years, support from the CNRS has kept pace with inflation and the needs to upgrade and modernize the laboratory. In order to obtain funding for new facilities, Professor Balkanski applied to the EC for a grant to develop new materials and processes that could be used to microfabricate solid-state batteries on silicon chips. This would permit the development of hybrid integrated circuits with bias sources incorporated in the chip. The EC funding provided support for an ultra high-vacuum molecular beam deposition system with all of the analytical capabilities that are necessary to characterize the metallic semiconductor and super-ionic conductor thin films used to fabricate the microscale batteries. The system is now operational and has been used to fabricate individual working batteries as well as integrated circuits consisting of a Josephson junction with a self-contained bias source.

Several features of this projects are typical of other EC-funded projects. The projects tend to be applied; the support is short term, mainly for equipment or facilities; and, while formally part of a multinational working group, each laboratory tends to do its own coordination mainly on a post-hoc basis. The level of coordination is not unusual considering the traditional independence of university professors and their equivalents in the research institutes. One of the major successes of EC-funded projects is that it has engendered a degree of communication and collaboration that has not been evident in the past in European laboratories.

The laboratories that I visited in Belgium, France, the FRG, the Netherlands and the U.K. were involved in basic and applied solid-state research, mainly semiconductors. The groups all appeared to be familiar with the various pan-European funding sources and the more active groups tended to have at least one external grant. Low-level funding does not appear difficult to obtain provided the research investigator and his laboratory are prepared to enter into the proposal process and all that it entails. For major funding from the larger EC programs, competition is intense and requires a level of involvement and political effort on a scale comparable with that in the U.S.

Ironically, the European research community is becoming increasingly immersed in the proposal process at a time when there are moves in the U.S. to find ways to reduce the scale of involvement of creative scientists in wasteful paper exercises. The rejection rates for the major programs are comparable to similar programs in the U.S. For a recent BRITE/EURAM submission for feasibility awards, 560 proposals were submitted, 111 survived the first screening, with about 50 expected to be funded ultimately. About one-third of these proposals were in advanced materials. In a parallel submission of

formal proposals for the BRITE/EURAM program, about one-third of the 520 Type I proposals from the industry sector were in advanced materials, while two-thirds of the 122 Type II proposals for focused university projects were materials-related. In the Phase II ESPRIT program, the first call for proposals drew 664 submissions, with 156 projects selected. Solid-state materials-related research comprises about one-third of the total.

The large increase in proposals has put a strain on the research community. The result is that the quality of the review and evaluation is not uniform. This was described

to me by the director of the central research laboratory for a major European electronics firm. He pointed out that previously, he and his advisors would be able to rank their proposals submitted to external agencies with a high degree of confidence. Recently, however, he finds little correlation between his internal ranking and that provided externally. Similarly, there appeared to be little coherency in the continuity of the review from one submission to the next. He said that corporate planning for resources required to carry out externally sponsored research was very difficult under these circumstances.

APPENDIX A
ACRONYMS USED IN THIS
PUBLICATION

APPENDIX A

ACRONYMS USED IN THIS PUBLICATION

AIM	Advanced Informatics in Medicine
ARPA	Advanced Research Projects Agency (U.S.)
ASIC	Application Specific Integrated Circuits
BAP	Biotechnology Action Program
BCR	community Bureau of Reference
BRAIN	Basic Research in Adaptive Intelligence and Neurocomputing
BRIDGE	Biotechnology Research for Innovation, Development, and Growth in Europe
BRITE	Basic Research in Industrial Technologies for Europe
CEC	Commission on the European Communities
CEN	Committee for Standards
CENELEC	Committee for Electrotechnical Standardization
CERN	European Organization for Nuclear Research
CNRS	Centre National de la Recherche Scientifique
COMETT	Community Action Program for Education and Training for Technology
CORDI	Advisory Committee on Research and Development
COST	Cooperation on Science and Technology
CTR	Controlled Thermonuclear fusion Research
DAMTP	Division of Applied Math and Theoretical Physics (Cambridge University, U.K.)
DELTA	Development of European Learning through Technological Advance
DG	Directorates General
DOSES	Development of Statistical Expert Systems
DRAM	dynamic random access memory
DRIVE	Dedicated Road Infrastructure for Vehicle Safety in Europe
EC	European Community
ECLAIR	European Collaborative Linkage of Agriculture and Industry through Research
ECSC	European Coal and Steel Community
ECMI	European Consortium for Mathematics in Industry
ECU	European Currency Unit
EEC	European Economic Community
EFTA	European Free Trade Association
EMBL	European Molecular Biotechnology Laboratory
EMBO	European Molecular Biology Organization
EPOCH	European Program on Climatology and Natural Hazards
ERASMUS	European Community Action Scheme for Mobility of University Students
ESA	European Space Agency
ESF	European Science Foundation
ESO	European Southern Observatory
ESPRIT	European Strategic Programme for Research and Development in Information Technologies
ESRF	European Synchrotron Radiation Facility
ESS	European Synchrotron Radiation Source
EURAM	European Research in Advanced Materials
EUREKA	European Research Coordination Agency (not an EC program)
EUROTRA	European Translation Program
FAMOS	Flexible Automated Assembly Project
FASE	Federation of Acoustical Societies of Europe
FAST	Forecasting Assessment in Science and Technology

FLAIR	Food Linked Argo-Industrial Research
FRG	Federal Republic of Germany
FY	Fiscal Year
GDP	Gross Domestic Products
GEC	British General Electric Company
GNP	Gross National Product
HDTV	High Definition Television
IAEA	International Atomic Energy Agency
IBC	Integrated Broadband Communications
ICF	Inertial Confinement Fusion
ICL	International Computers Limited
ICs	integrated circuits
ILL	Institut Laue-Langevin, Grenoble
ISDN	Integrated Services Digital Network
IT	Information Technology
ITER	International Tokamak Engineering Reactor
JASA	Journal of the Acoustical Society of America
JESSI	Joint European Submicron Silicon Initiative
JET	Joint European Torus
JOULE	Joint Opportunities for Unconventional or Long-Term Energy Supply
JRC	Joint Research Centers
LDC	least developed countries
LFRs	less-favored regions
MAST	Marine Science and Technology
MBI	Medical and Bio-Informatics
NET	Next European Torus
NICs	Newly Industrializing Countries
OECD	Organization for Economic Cooperation and Development
OSI	Open Systems Interconnection
PROMETHEUS	Programme for a European Traffic System with Highest Efficiency and Unprecedented Safety
RACE	Research and Development in Advanced Communication in Europe
R&D	Research and Development
RTD	Research and Technology Development
S&T	Science and Technology
SAST	Strategic Analyses in the Field of Science and Technology
SCIENCE	Stimulation des Coopérations Internationales et des Echanges Nécessaires aux Chercheurs en Europe
SME	Small Manufacturing Entities
SPES	Stimulation Plan for Economic Science
SPEAR	Support Program for the Evaluation Activities in the Field of Research
SPRINT	Strategic Program for Innovation and Technology
SSC	Superconducting Super Collider
STC	Standard Telephone and Cables
STD	Science and Technology for Development
STEP	Science and Technology for Environmental Protection
STRIDE	Science and Technology for Regional Innovation and Development in Europe
TELEMAN	Telemanipulator research program
TIPs	Technical Integration Projects
VALUE	Valorization and Utilization for Europe
VAT	value-added tax

APPENDIX B

EUROPEAN COMMISSION

DIRECTORATES GENERAL

APPENDIX B**EUROPEAN COMMISSION DIRECTORATES GENERAL**

DGI	External Relations
DGII	Economic and Financial Affairs
DGIII	Internal Market and Industry
DGIV	Competition
DGV	Employment, Social Affairs, Education
DGVI	Agriculture
DGVII	Transport
DGVIII	Development
DGIX	Personnel and Administration
DGX	Information and Culture
DGXII	Environment, Consumer Protection, Nuclear Safety
DGXIII	Science and Research
DGXIV	Telecommunications, Information Industries, Innovation
DGXV	Fisheries
DGXVI	Financial Institutions and Company Law
DGXVII	Regional policy
DGXVIII	Energy
DGXIX	Credits and Investments
DGXX	Budgets
DGXXI	Financial Control
DGXXII	Customs Union and Indirect Taxation
DGXXIII	Coordination of Structural Instruments

APPENDIX C

**ARTICLES CONCERNING SCIENTIFIC PROGRAMS
AND EC GOALS FOR 1992**

APPENDIX C

ARTICLES CONCERNING SCIENTIFIC PROGRAMS
AND EC GOALS FOR 1992

The following articles concerning scientific programs and EC goals for 1992 were published during 1988/89 and copies are available from ONREUR. To request copies of the following articles, check the number on the self-addressed mailer and return it to ONREUR.

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